N73-28252

Paper G 21

REGIONAL TECTONIC CONTROL OF TERTIARY MINERALIZATION AND RECENT FAULTING IN THE SOUTHERN BASIN-RANGE PROVINCE, AN APPLICATION OF ERTS-1 DATA

I. C. Bechtold, M. A. Liggett and J. F. Childs, *Argus Exploration Company, Newport Beach, California*

ABSTRACT

Research based on ERTS-1 MSS imagery and field work in the southern Basin-Range Province of California, Nevada and Arizona has shown regional tectonic control of volcanism, plutonism, mineralization and faulting. This paper covers an area centered on the Colorado River between 34°15' N and 36°45' N. During the mid-Tertiary, the area was the site of plutonism and genetically related volcanism fed by fissure systems now exposed as dike swarms. Dikes, elongate plutons, and coeval normal faults trend generally northward and are believed to have resulted from east-west crustal extension. In the extensional province, gold and silver mineralization is closely related to Tertiary igneous activity. Similarities in ore, structural setting, and rock types define a metallogenic district of high potential for exploration. The ERTS imagery also provides a basis for regional inventory of small faults which cut alluvium. This capability for efficient regional surveys of Recent faulting should be considered in land use planning, geologic hazards study, civil engineering and hydrology.

INTRODUCTION: This report summarizes a portion of a NASA funded investigation intended to test the application of ERTS-1 imagery to studies of regional tectonics. The region discussed in this paper occupies a belt approximately 25 miles wide and 125 miles long aligned along the Colorado River between 34°15' and 36°34' N latitude in the Basin-Range province of southern Nevada, southeastern California and northwestern Arizona. This area is shown in Figure 1.

The primary tool used in the investigation is additive color enhancement of ERTS-1 MSS imagery. The synoptic perspective gained in ERTS imagery permits investigation of regional geologic phenomena at a scale not feasible using conventional aerial photography. As a complement to ERTS data, intermediate scale remote sensing imagery and low altitude aerial reconnaissance has proven valuable in guiding efficient and economical ground based geologic reconnaissance. The primary data used in this study includes:

NASA ERTS-1 MSS	12 September 1972, Frame 1069-17432
	5 November 1972, Frame 1105-17443
	6 November 1972, Frame 1106-17495

PRECEDING PAGE BLANK NOT FILMED

NASA Apollo 9 Ektachrome		Frames AS9-20-3135; 3136
NASA SLAR AN/APQ 97, 5 November 1965		Mission 103
USAF-USGS U-2 Black and White Photography		
	10 July 1968	Mission 018
	17 July 1968	Mission 059
	6 Sept. 1968	Mission 374
NASA U-2 Color Infrared Photography		
	11 Oct. 1971	Mission 189

REGIONAL TECTONICS: In the ERTS-1 image of Figure 1, a belt of anomalous north-south topographic, textural and color expression is visible along the Colorado River. Structural analysis of this imagery and related literature research and ground based reconnaissance has led to a hypothesis integrating many aspects of the regional geology previously considered as isolated phenomena.

We believe the anomalous north-south structural pattern is the result of east-west crustal extension of at least 30 km which occurred during an episode of Miocene plutonism and genetically related volcanism. The bulk of igneous activity occurred in an interval from 10 to 15 million years B.P. (Anderson & Others, 1972) and was synchronous with major strike-slip displacement on the Las Vegas Shear Zone (Fleck, 1970). We believe the Las Vegas Shear Zone extends eastward just north of Lake Mead, and forms the northern boundary of the extensional province. This tectonic relationship is illustrated in the simplified model of Figure 2. Here the strike-slip fault zone (X-Y) is a transform fault bounding two areas of crustal extension (braided patterns). The southern extensional province corresponds to the area described in this paper; a sister province is believed to exist in the vicinity of the AEC Nevada test site, 75 miles north-west of Lake Mead.

A diagrammatic section across an area of crustal extension is shown in Figure 3. Normal faults related to extension, shown in Figure 3, are believed to decrease in dip downward and give way at depth to a zone of plastic deformation (Stewart, 1971). Extension by low dipping normal faults in a thick Tertiary volcanic sequence near Nelson, Nevada has been described by Anderson (1971). Another mechanism of crustal extension is the addition of new crust by plutonism and related volcanism; in part along extensional fault zones (Bechtold et al, 1972). Figure 4 shows the distribution of Tertiary granitic plutons and related dike swarms in the area of investigation. Dings (1951) describes numerous large rhyolite dikes in the Wallapai Mining District north of Kingman, Arizona. Petrographic and chemical similarities among the volcanics, dikes and larger plutonic bodies have been demonstrated by Volborth (personal communication, 1972) for the Newberry Mountains area, Nevada. Temporal and genetic relationships between plutonic and volcanic rocks within the area have been cited by Volborth (personal correspondence 1972), Lausen (1931), Ransome (1923), Bechtold et al, (1972), Callaghan (1939), and Anderson et al, (1972).

MINERALIZATION: The shallow granitic plutons and dike swarms of Figure 4 are closely related to extensive gold, silver and lesser copper-molybdenum mineralization. Figure 5 shows the distribution of known mining areas in the region. Longwell et al (1965) briefly discuss many Nevada mining districts, and Ransome (1923), Callaghan (1939) and others describe some of the larger mining areas in detail. Review of the literature and geologic reconnaissance has revealed marked similarities in the structural setting, ore and gangue mineral assemblages, and rock type associations among mining areas. The gold-silver deposits along the Colorado River are part of a north-trending metallogenic province genetically related to the Tertiary extensional deformation. This regional structural control of mineralization has not been previously reported. The value of ore recovered in this province (based upon 1973 metal prices) exceeds 100 million dollars. Although mining activity is largely inactive at present, the new understanding of the area made possible by ERTS data merits consideration in future mineral exploration programs.

RECENT FAULTING: In addition to regional tectonic syntheses, ERTS data has provided a basis for efficient geological reconnaissance of relatively small faults which cut alluvium. Most of the faults cut alluvium of probable Recent age.

Figure 6 shows the distribution of these faults identified in ERTS and intermediate scale imagery and confirmed during subsequent reconnaissance and detailed field mapping. Faults previously reported (Longwell, 1963) and confirmed by our imagery analysis are distinguished from newly recognized faults. Displacement is mainly dip slip, and in several instances the faults form small grabens (Bechtold et al, 1973). Many of the faults occur out from the range fronts in intermontane alluvial sediments where they are difficult to recognize in ground-based mapping. The faults trend generally northward and probably represent late-Tertiary to Recent east-west extension similar to that recognized elsewhere in the Basin-Range Province (Thompson, 1967).

The use of ERTS-1 imagery for efficient reconnaissance of Recent faulting over large areas of semi-arid terrain can have important applications in the planning and design of engineering projects such as dams, highways and nuclear power generating stations. Related applications can also be made in regional geologic hazard studies and in the search for increasingly valuable ground water sources.

CONCLUSIONS: ERTS-1 MSS imagery is a unique tool for a broad range of geologic investigations, some of which are discussed above. Analysis of ERTS data coordinated with the use of other remote sensing techniques has permitted efficient and economical ground-based reconnaissance. At a regional scale, the application of ERTS to tectonics shows promise in reconnaissance mineral exploration. In addition, the resolution of the ERTS-MSS imagery is sufficient for surveys of relatively small faults which cut alluvium. This capability should be considered in land-use planning, geologic hazards study, and civil engineering.

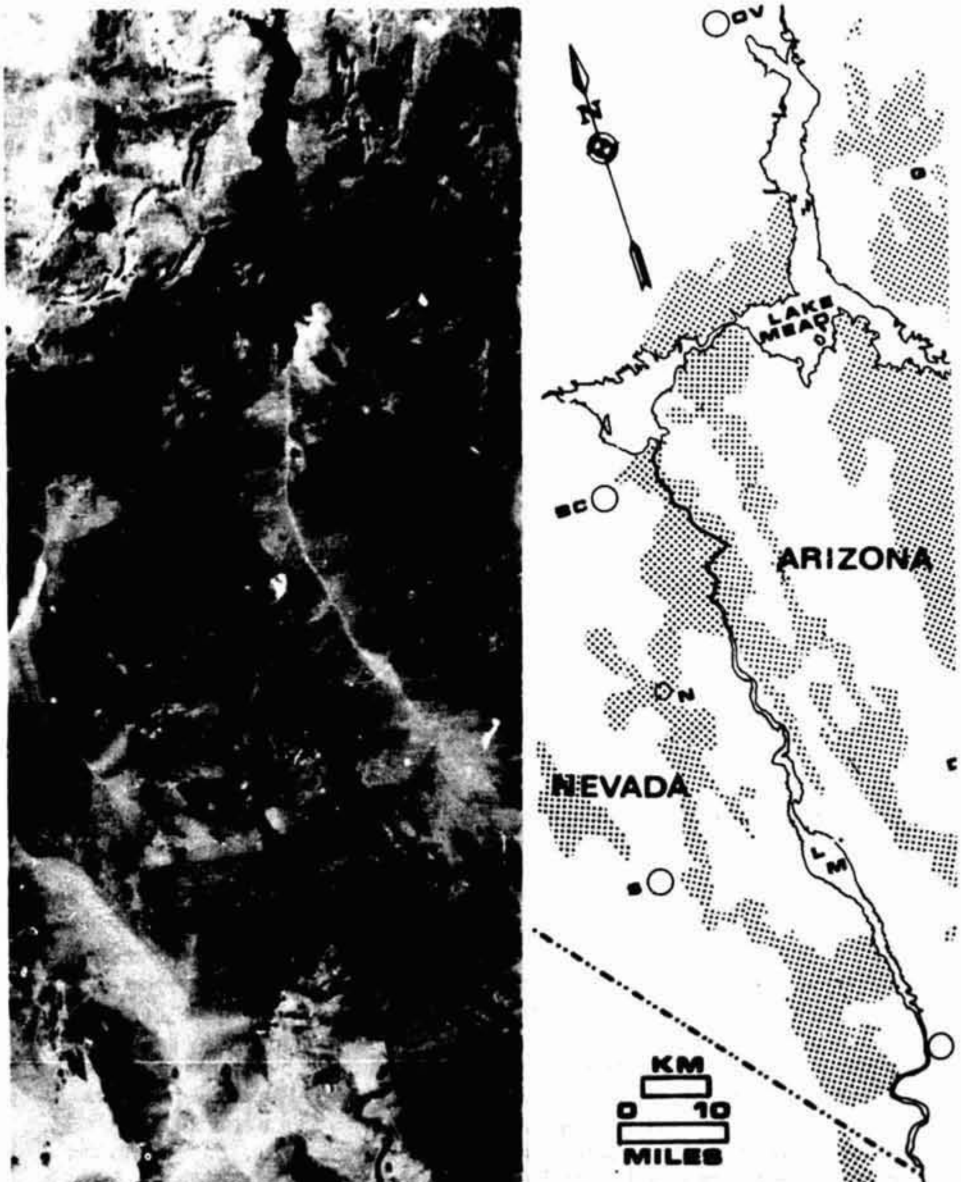


Figure 1: Portion of ERTS-1 MSS image 1106-17495-7 and index map of the study area. Location names are as follows:

B	-	Bullhead City, Ariz.	LM	-	Lake Mojave
BC	-	Boulder City, Nev.	N	-	Nelson, Nev.
DV	-	Detrital Valley, Ariz.	OV	-	Overton, Nev.
G	-	Gold Butte, Nev.	S	-	Searchlight, Nev.

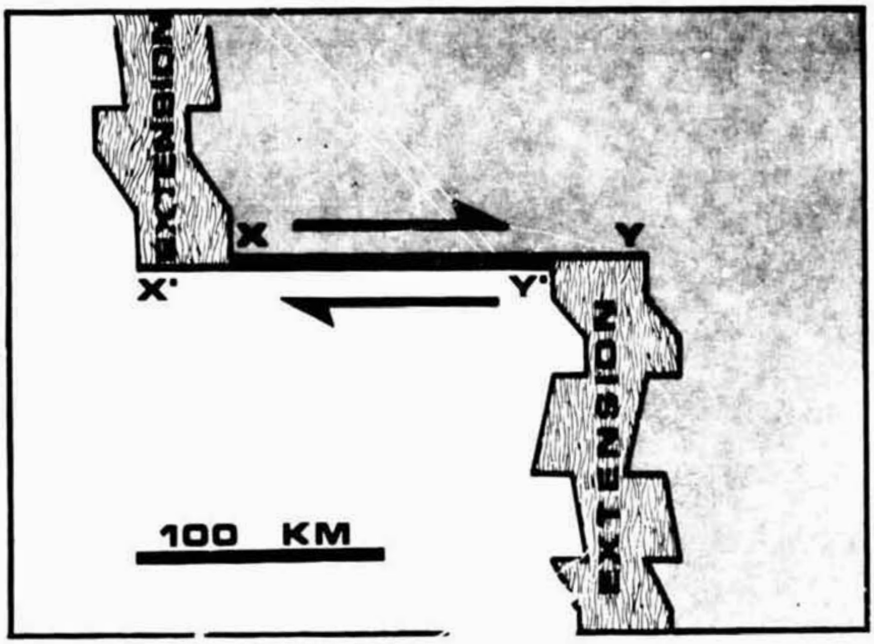


Figure 2.
Simplified tectonic diagram of a transform fa -Y) separating two areas of crustal extension (braided patterns). The shaded and white areas represent two crustal "plates". The Las Vegas shear zone is believed to be the transform fault which forms the northern boundary of an extensional province along the Colorado River.

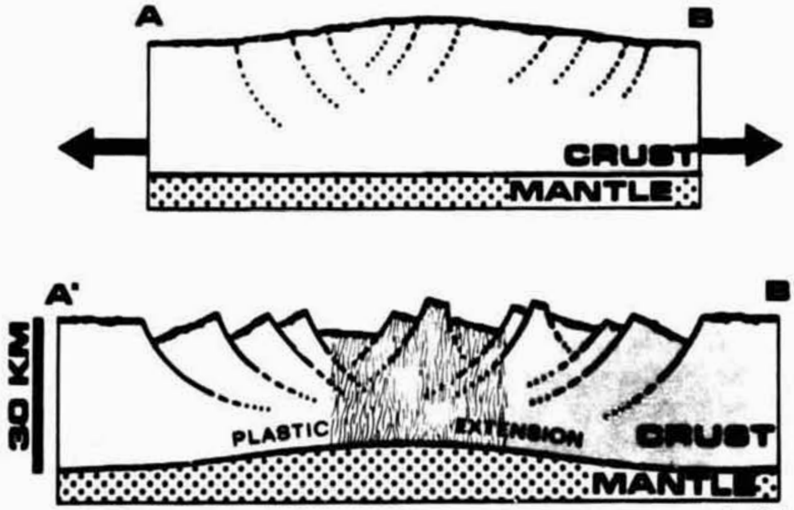
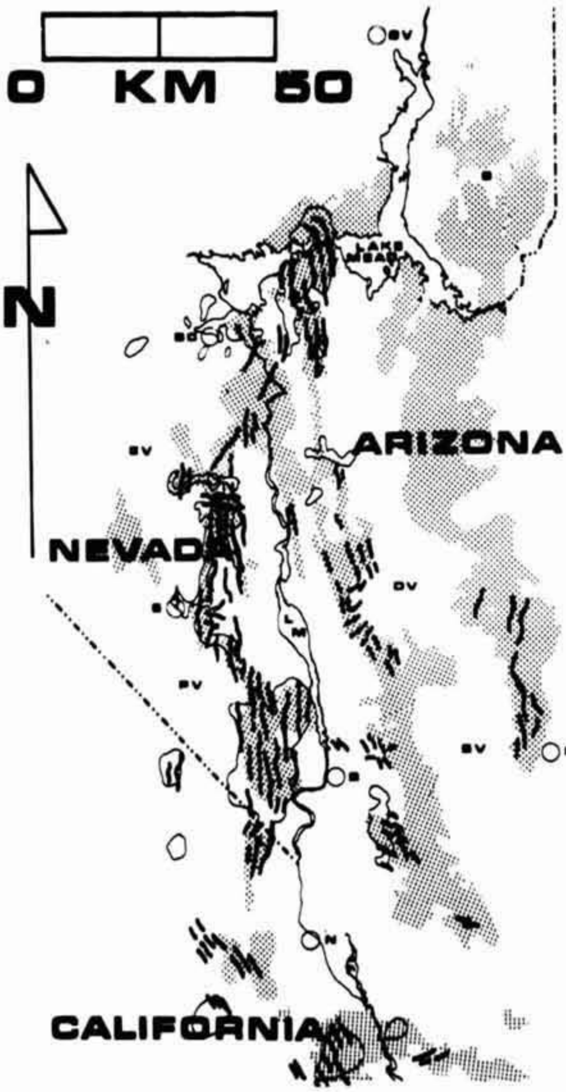


Figure 3.
Vertical sections of a region before and after crustal extension. Mechanisms of extension are normal faulting, plastic extension in the lower crust, and formation of new crust by volcanism and plutonism (braided pattern).



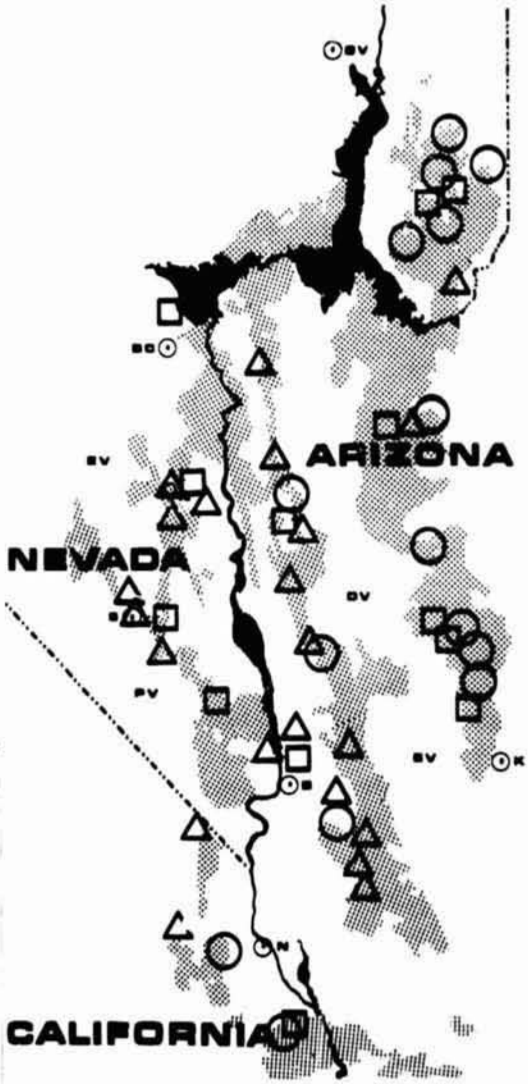


Figure 4. Distribution of Tertiary intrusive rocks, believed emplaced during crustal extension. Granitic plutons are outlined, and dike swarms are shown with heavy lines. Stippled areas are generalized bedrock exposures. Location names are as in Figures 1 and 6.

Figure 5. Distributions of known mineral deposits are indicated by triangles for gold; squares for lead, zinc, and silver; and circles for copper and molybdenum. Stippled areas are generalized bedrock exposures. Location names are as in Figures 1 and 6.

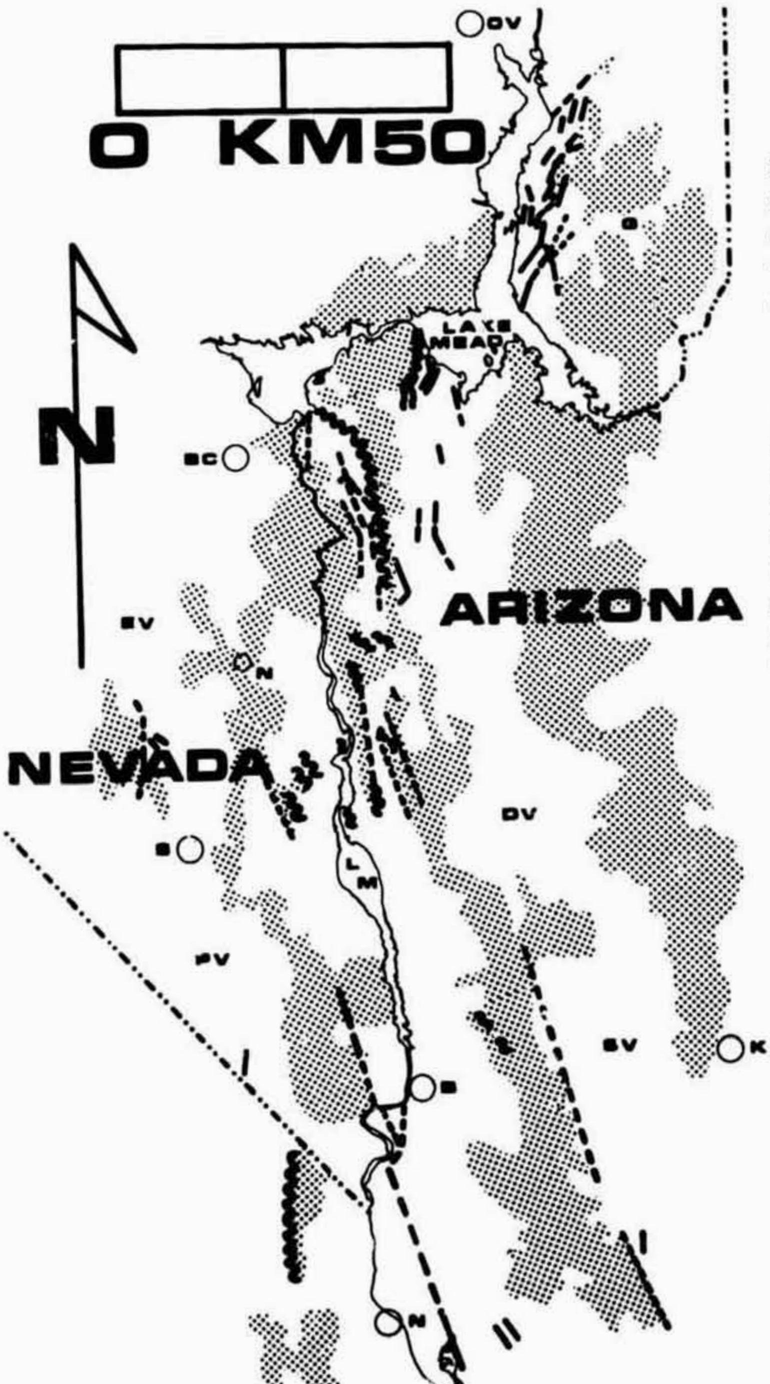


Figure 6. Newly recognized faults which cut alluvium are shown with solid lines where distinct; dashed lines where indefinite. Previously reported faults in alluvium, also apparent in ERTS imagery, are shown with wiggled lines. Faults cutting bedrock have been excluded. Stippled areas are generalized bedrock exposures. Location names are as in Figure 1, with the following additions:

EV-Eldorado Valley
K-Kingman, Ariz.
N-Needles, Calif.
PV-Piute Valley
SV-Sacramento Valley

REFERENCES

Anderson, R. E., 1971, Thin Skin Distension in Tertiary Rocks of Southeastern Nevada: Geol. Soc. America Bull., v. 82, p 43-58.

Anderson, R. E., Longwell, C. R., Armstrong, R. L., and Marvin, R. F., 1972, Significance of K-Ar Ages of Tertiary Rocks from the Lake Mead region, Nevada-Arizona: Geol. Soc. America Bull., v. 83, No. 2, p 273-288.

Bechtold, I. C., Liggett, M. A., and Childs, J. F., 1972, Structurally Controlled Dike Swarms Along the Colorado River, Northwestern Arizona and Southern Nevada (ABS): NASA-CR-128290, E72-10192.

Bechtold, I. C., Liggett, M. A., Childs, J. F., 1973, Remote Sensing Reconnaissance of Faulting in Alluvium, Lake Mead to Lake Havasu, California, Nevada and Arizona: NASA Report of Investigation, Goddard Space Flight Center, Greenbelt, Maryland.

Callaghan, E., 1939, Geology of the Searchlight District, Clark County, Nevada: U. S. Geological Survey Bulletin 906-D, p 165-185.

Dings, G., 1951, The Wallapai Mining District, Cerbat Mountains, Mojave County, Arizona: U. S. Geol. Survey Bull. 978-E, 39 p.

Fleck, R. J., 1970, Age and possible Origin of the Las Vegas Shear Zone, Clark and Nye Counties, Nevada: Geol. Soc., America Abs. with Programs (Rocky Mountain Sec.), v. 2, No. 5, p 333.

Lausen, G., 1931, Geology and Ore Deposits of the Oatman and Katherine Districts, Arizona: Arizona Bur. Mines Bulletin 131, Geol. Ser. 6, (Univ. Bull., v 2, No. 2), 126 p.

Longwell, C. R., 1963, Reconnaissance Geology Between Lake Mead and Davis Dam, Arizona-Nevada: U. S. Geol. Survey Prof. Paper 374-E, 51 p.

Longwell, C. R., Pampeyan, E. H., Bowyer, B., and Roberts, R. J., 1965, Geology and Mineral Deposits of Clark County, Nevada: Nevada Bur. Mines Bull. 62, 218 p.

Ransome, F. L., 1923, Geology of the Oatman District, Arizona, A Preliminary Report: U. S. Geol. Survey Bull. 743, 58 p.

Stewart, J. H., 1971, Basin and Range Structure: A System of Horsts and Grabens Produced by Deep-Seated Extension: Geol. Soc. America Bull., v. 82, p 1019-1044.

Thompson, G. A., Meister, L. T., Herring, A. T., Smith, T. E., Burke, D. B., Kovach, R. L., Burford, R. O., Salehi, A., and Wood, M. D., 1967, Geophysical Study of Basin-Range Structure, Dixie Valley Region, Nevada: U. S. Air Force Cambridge Research Labs. Spec. Rept. 66-848.

Volborth, A., 1972. Personal Communication. Nevada Bureau of Mines, Reno, Nevada.