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JDS

ASARCO EXPLORATION RECORD

[X] FIELD EXAMINATION [ ] LITERATURE SEARCH [ ] ASARCO FILE [ ] _____

Section I General Indexing

① Name(s) of Property or Area	② Country	③ State or Province
Mohawk Pass	USA	Arizona

④ USGS Quad.	⑤ File or Core No.
Mohawk Mts. NW 7½'	

⑥ Latitude	⑦ Longitude	⑧ AMS Sheet	Township	Range	Section	⑨ Examined by	⑩ Date
32°44'N	113°45'W	Ajo	8S	15W	11, 12, 13	J.D. Sell	5/23/85
						⑪ Office: Tucson	⑫ Field Days: partial

Section II Sources of Information

Date Typed 6/24/85

⑬ References

Author	Date	Title	Publications	Vol. No.
S.B.Keith, 1978, Index of Mining Properties in Yuma Co., AZ; AZ B.G&MT, Bulletin 192, pages 59-60, 125, 136 & 163.				
Mueller, K.J., 1982, Mid-Tertiary Detachment Faulting in the Mohawk Mtns, SW AZ: in Meso-Ceno Tect. Evol. of Colo. River Region (Anderson-Hamilton Volume), p. 448-457.				

Section III Appraisal

⑭ Recommendations
- [ ] Action Now
- [ ] Too Low Grade
- [ ] Too Small
- [ ] Ownership Problem
- [ ] Access Problem
- [X] Follow-up

⑮
- [ ] Post Producer
- [ ] Producer
- [ ] Mineral Deposit
- [X] Prospect
- [ ]

- [ ]
- [X] Geologic Concept
- [ ] Geochem Anomaly
- [ ] Geophy Anomaly
- [ ]

⑯ Production Commodity: None

⑰ Reserves
- [ ] Measured Commodity: None

⑱ Num. Drill Holes _____ Approx Total Footage _____

⑲ Excavations: Several prospects

⑳ [ ] Spectro. Analysis Attached ㉑ [ ] Assays Attached ㉒ [X] Geochem Results Attached TAJ-428

SY-19-62
6-24-85
Goldfields

Section IV Geologic Data

㉓ Commodity or Contained Metals: Trace Copper

㉔ Ore Minerals-Major: Oxide Zone Minor: _____

㉕ Host Rocks-Major: Detachment Zone Minor: _____

㉖ Age of Host Rocks: Mesozoic metamorphics, Jurassic? granite

㉗ Nature of Exposures: Footwall metamorphics and hanging wall granite exposed in hills; detachment zone mostly in saddles in wash drainages, i.e. poor exposures.

㉘ Alteration: Minor epidote at SY - sample area.

㉙ Total Extent: Probably several miles strike length.

㉚ Structure: Detachment zone tens to 100's(?) feet thick, dipping 20°-30° to NE, striking northwesterly.

㉛ Ore Occurrence: Strong Fe oxide, 5-10 feet thick at SY - area. Barite, fluorite reported at Renner Mine in Sec. 11.

㉜ Age of Mineralization: Late Mesozoic? - or Tertiary?

㉝ Conclusions & Recommendations: Typical setting of detachment zone type with metamorphic complex on footwall and brecciated granite on hanging wall. Other prospects to northwest (not looked at). Total zone should be reviewed. Shaft in Sec. 11 (Renner mine) apparently shipped 18 carloads of barite in 1929-30.

(For additional space use extra sheets)

Form Revised-June 1980-J.H.C. MVK 5193

ASARCO

Southwestern Exploration Division

June 4, 1985

To: W. L. Kurtz

From: J. D. Sell

Review Trip
Detachment Zones
May 20-29, 1985

During this time period I visited a number of areas with suspected detachment zones capable of having clues to an ore deposit. Some zones were initially seen by viewing from the highway, others were submittals, and some were from the Winter Program.

1. Mohawk Pass, Yuma County, AZ

On Interstate 8 (Tucson-Yuma) approximately 12 miles west of Dateland interchange, the east side of the Mohawk Mountains shows a core complex main mass with light colored granite slabs attached as spurs extending easterly.

A good exposure of the detachment surface can be seen by taking the Mohawk Valley off-ramp west (Ave. 52E) onto old US 80 and approximately ½ mile to Milepost 57.2. At this roadcut area the hanging wall brecciated granite can be viewed as well as the footwall sequence. Back to the southeast toward the railroad tracks, a line of pits and trenches probe the detachment zone itself. One pit, near a saddle is 4' x 6' x 5' deep and exposes the best red-black iron oxide. A competitor aluminum tag #SY-19-62 is nailed in the wall. I collected three samples from top to bottom on the north wall.

SY-19-62-1	1½ feet of sheared iron-stained granitoid.
SY-19-62-2	1 foot of fractured rhyolite sill subparallel to zone.
SY-19-62-3	3 foot sheared, heavy (+10%) FeOx red-black limonite and quartz seams with minor chloritic material.

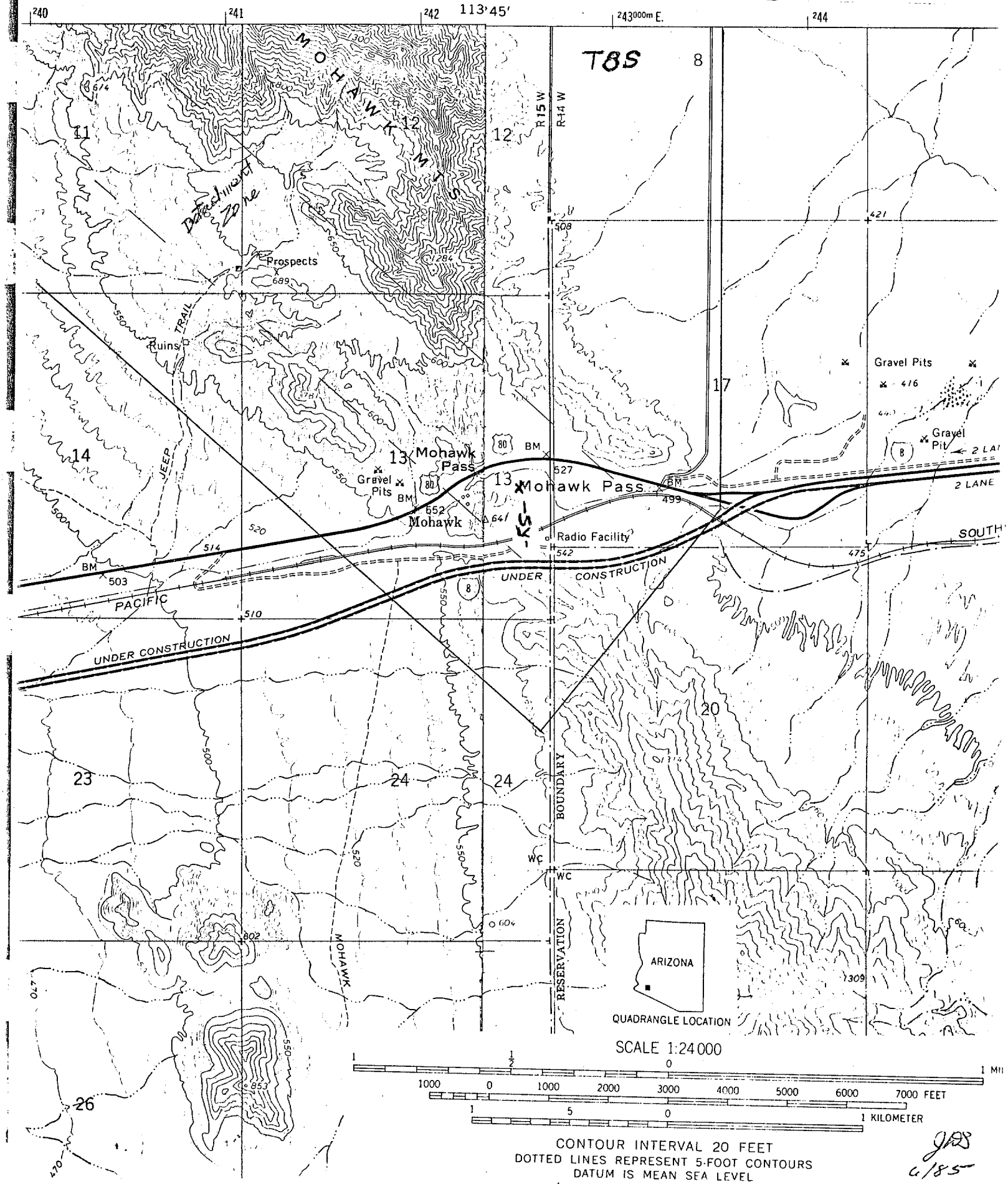
The zone trends northwesterly and dips 20°-30° northeasterly. The footwall is various sheared subparallel to the detachment zone with epidote and some iron-staining, mapped as Mesozoic schist. The detachment zone itself is variable in thickness, but may be up to 50 feet in thickness in some areas. The hanging wall is brecciated, Mesozoic granite, and forms a ¼-½ mile topographic valley to the northeast prior to rising up into the hills.

As several miles of space are available northwesterly and southeasterly from the pass before the farm lands or Gunnery Range is reached, the zone should be further reconnaissanced, sampled, and mapped as an environment to host a detachment type deposit.

MOHAWK QUADRANGLE
ARIZONA—YUMA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 MOHAWK 15' QUADRANGLE

MOHAWK MTS. NW, ARIZ.
N3237.5—W11337.5/7.5

1965



CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

JRS
6/85

SKYLINE LABS, INC.
1775 W. Sahuaro Dr. • P.O. Box 50106
Tucson, Arizona 85703
(602) 622-4836

REPORT OF ANALYSIS

JOB NO. TAJ 428
June 13, 1985
SY-19-62 (1-3)
PAGE 1 OF 1

ASARCO INCORPORATED
Attn: Mr. James D. Sell
Southwestern Exploration
P.O. Box 5747
Tucson, Arizona 85703

ASARCO Incorporated
JUN 14 1985
SW Exploration

Analysis of 3 Rock Chip Samples

ITEM	SAMPLE NUMBER	Au (ppm)	Ag (ppm)	As (ppm)	Sb (ppm)	Mo (ppm)
1	SY-19-62-1	<.1	.10	2.	4.	6.
2	SY-19-62-2	<.1	.10	2.	<2.	2.
3	SY-19-62-3	<.1	.05	4.	2.	8.

ITEM	SAMPLE NUMBER	Bi (ppm)	Cd (ppm)	Tl (ppm)	Cu (ppm)	Te (ppm)
1	SY-19-62-1	<1.	<.1	<1.	85.	<1.
2	SY-19-62-2	<1.	<.1	<1.	40.	<1.
3	SY-19-62-3	<1.	<.1	<1.	175.	<1.

cc: Asarco Incorporated
Attn.: Ms. Mary Kavanagh
Southwestern Exploration
P.O. Box 5747
Tucson, Arizona 85703

REGISTERED ASSAYER CERTIFICATE NO. 9425 WILLIAM L. LEHMBECK STATE OF ARIZONA

William L. Lehmbeck
Manager

ANDERSON-HAMILTON VOLUME

missed this in my pass thru the volume, prior to going in the field. [illegible]

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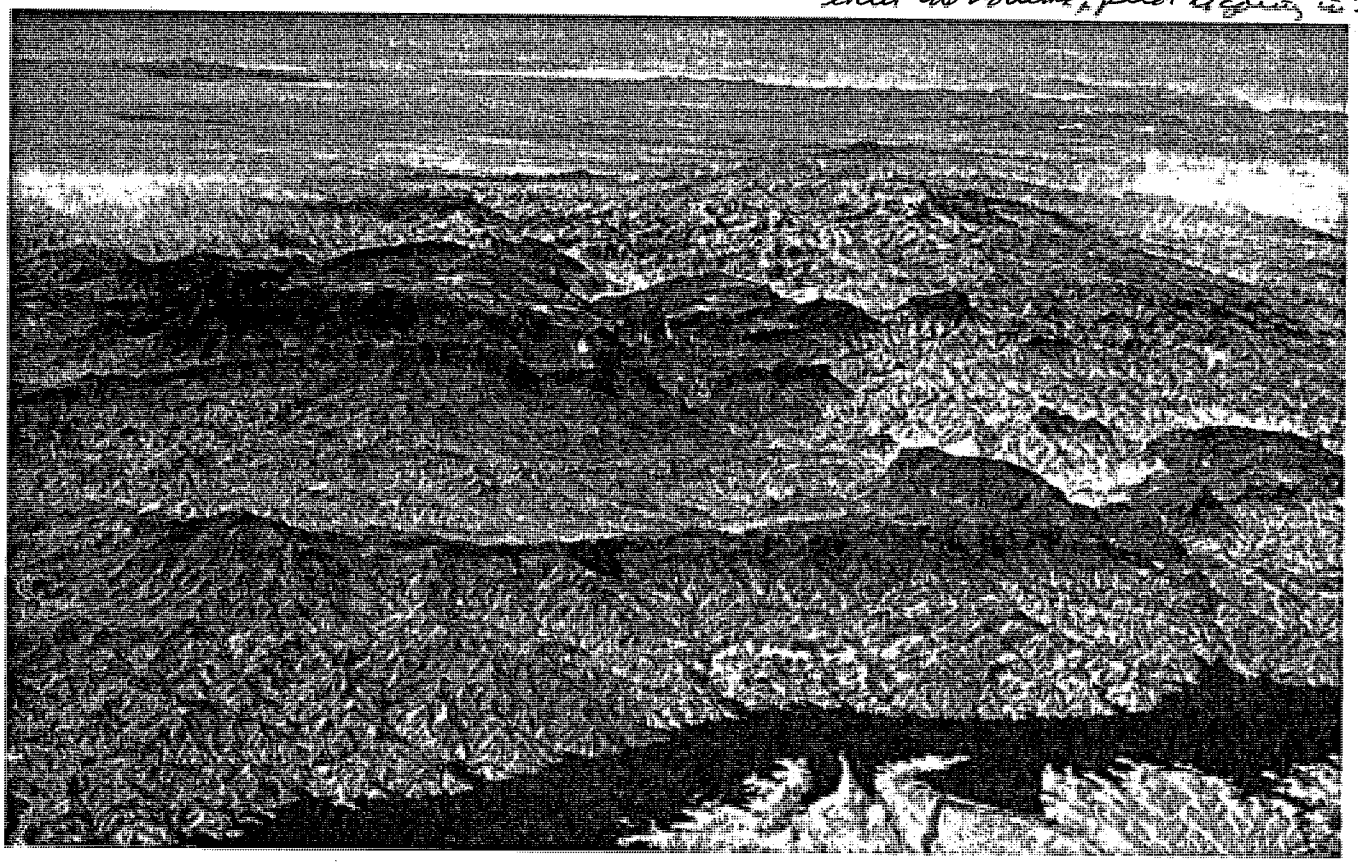
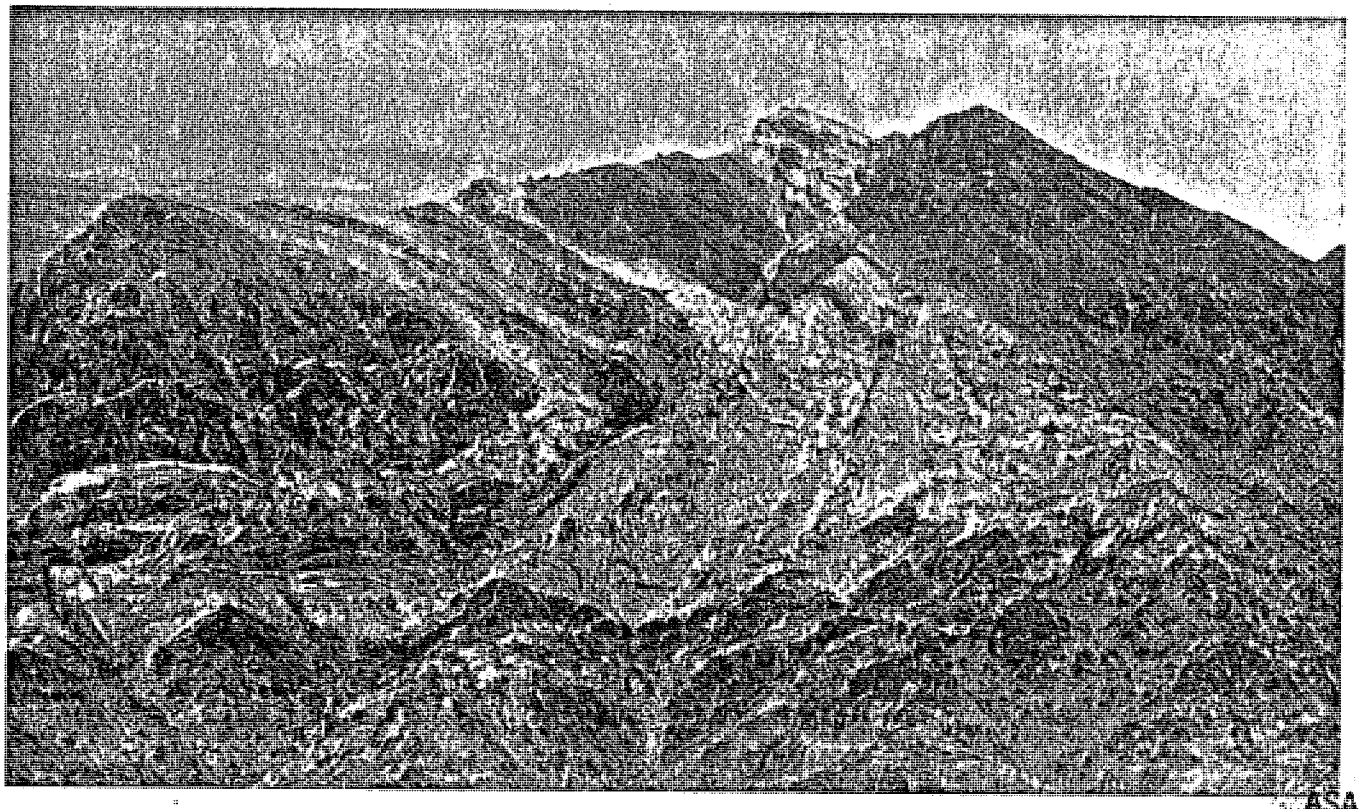


MESOZOIC-CENOZOIC TECTONIC EVOLUTION OF THE COLORADO RIVER REGION, CALIFORNIA, ARIZONA, AND NEVADA

1982



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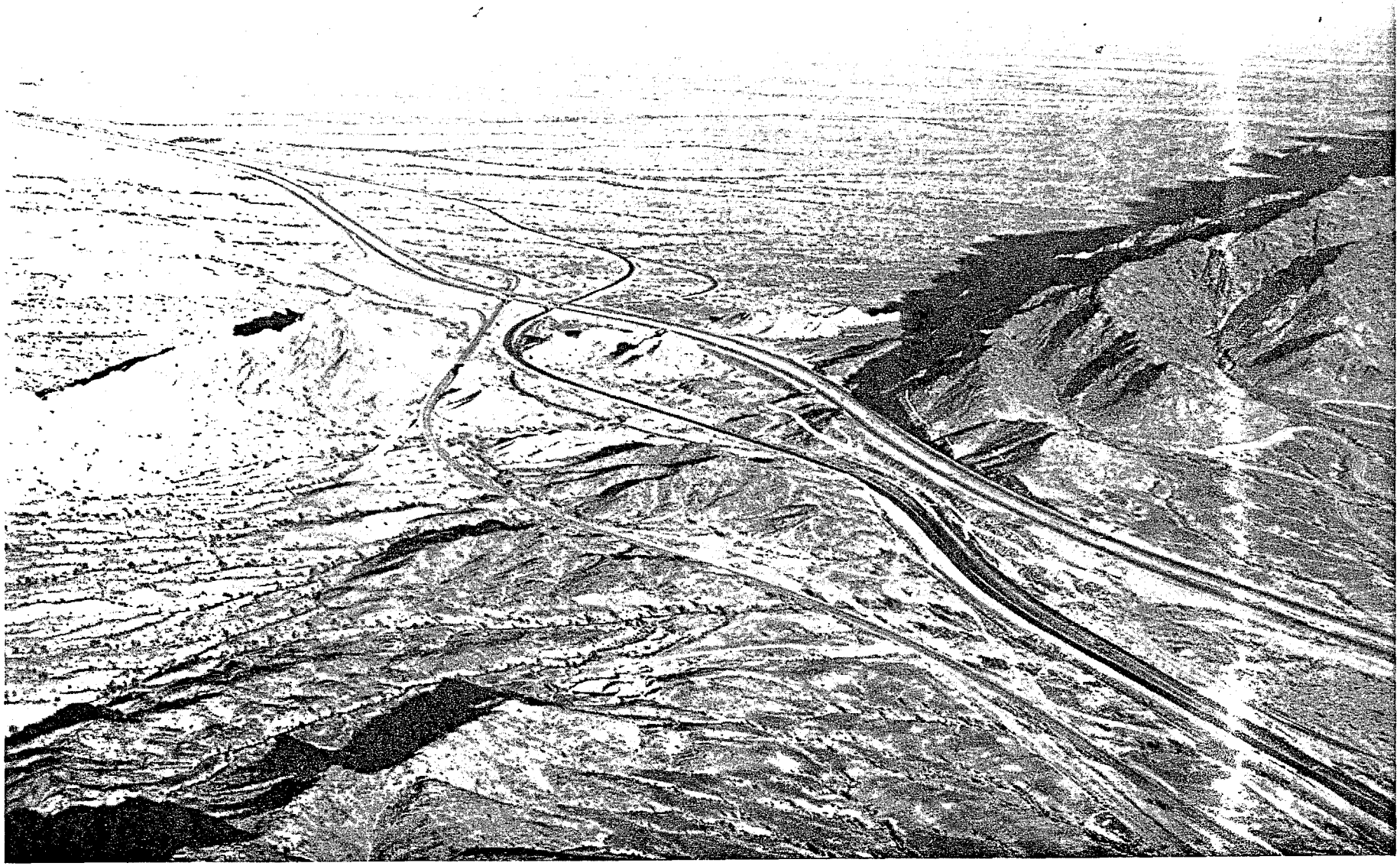

View of Mohawk Pass and Interstate 8 with the Mohawk detachment fault separating light-colored, upper-plate rocks from dark-colored, lower-plate rocks. View is looking to the southeast toward Sonora.

MID-TERTIARY DETACHMENT FAULTING IN THE MOHAWK MOUNTAINS OF SOUTHWESTERN ARIZONA

Karl J. Mueller and Eric G. Frost
Department of Geological Sciences
San Diego State University
San Diego, California 92182

Gordon Haxel
U. S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

ABSTRACT

The Mohawk Mountains of southwestern Arizona contain a major low-angle normal fault, or detachment fault, of Tertiary age. The fault is marked by brecciation, alteration and locally mineralization. This northeast-dipping fault is defined by the location of numerous klippen on the eastern side of the range, which are exposed south of Interstate 8 for approximately 25 km. The fault separates a lower plate composed of heterogeneous Precambrian gneiss from an upper plate composed of both crystalline and sedimentary units. These include a hornblende-biotite granite and a biotite granite, both of which are depositionally overlain by a northnorthwest-dipping sequence of interbedded mid-Tertiary sediments composed primarily of debris-flow conglomerate, sedimentary breccia, and arkosic sandstone of fluvial origin.

Upper-plate antithetic and synthetic faults exposed along the crest of the range north of Interstate 8 cut all three upper-plate units and extend them in a northeast-southwest direction. The amount of upper-plate extension displayed by these faults does not appear great. However, there appears to be a gross mismatch of upper and lower-plate units, suggesting significant offset across the detachment fault. The actual amount of this offset is unknown.

The lower-plate rocks have a well-developed foliation that consistently dips to the southeast, and is truncated at a high angle by the detachment fault. These foliated lower-plate rocks are not mylonitic and do not contain the well-developed lineation characteristic of the "core complex" terrane to the north and east. The presence of well-developed detachment faulting without mylonitic or lineated rocks suggests that mylonitization and detachment faulting are not genetically related. The presence of detachment faulting this far to the southwest in Arizona significantly increases the known area of detachment faulting and indicates the strong possibility of seeing such mid-Tertiary extension in northern Sonora and in the vicinity of the San Andreas transform system in southern California and Baja California.

INTRODUCTION

The northern Mohawk Mountains lie approximately 90 km east of Yuma, Arizona, along Interstate 8. The freeway crosses the range at Mohawk Pass, (Fig. 1) from where the range extends some 65 km southeast of the pass and approximately 7 km northwest of the pass.

This study involved mapping the northern Mohawk Mountains to determine the extent and character of a locally exposed portion of a regional fault inferred to be present in most of southwestern and central Arizona. This low-angle normal fault, herein called a detachment fault, is associated with several distinct structural features. The purpose of this work was to determine, through field study of these structural features, the overall structural history of the Mohawks and the genetic link, if any, to regional crustal extension and detachment faulting of mid-Tertiary age. Some of the structures studied include the detachment fault, itself; upper-plate antithetic and synthetic faults; and arching or re-orientation of the detachment surface. Also studied was the altered and mineralized zone of breccia and microbreccia, which is present directly below the fault.

Access

Overall access to the Mohawks is generally poor, with none extending south of the freeway except by foot. Permission is needed to enter any land south of the freeway from several sources, including the Cabeza Prieta Wildlife Refuge, the Gila Bend Auxilliary Air Force Base (Luke Air Base), and the U.S. Army Proving Grounds. Access to the range north of the freeway is much better since permission is not needed to enter this area. A well-graded road, Avenue 52, extends from Mohawk Pass to the northern tip of the range providing relatively easy access. Extreme caution must be exercised when traversing the northern part of the range due to the ruggedness of the terrain and the abundance of loose rock.

Previous Work

Little previous work has been done on the Mohawk Mountains and its surrounding region. In their study of the Cenozoic stratigraphy of southwestern Arizona, Eberly and Stanley (1978) consider the upper-plate sedimentary rocks of the Mohawks to belong to their older sequence of Tertiary units. They interpret these rocks to have been deposited before the onset of local basin and range, high-angle normal faulting. Tucker (1980) studied the geomorphic expression of faulting within this region and concluded that the margins of the Mohawk Mountains have been tectonically inactive since late Miocene or early Pliocene time. Geophysical study of the region by Oppenheimer and Sumner (1980) and T. Brown (written commun., 1981) indicates that the basin west of the Mohawks drops off sharply just west of the range and then rises gradually to rock outcrops in the adjacent Baker Peaks-Antelope Hill area. Ongoing Survey work for the Ajo two-degree sheet, under the supervision of Gordon Haxel, has produced a regional reconnaissance of most of the ranges east and south of the Mohawks. Geochronological study of the Precambrian rocks of the range has been undertaken by L. T. Silver, but results of his work are not yet available.

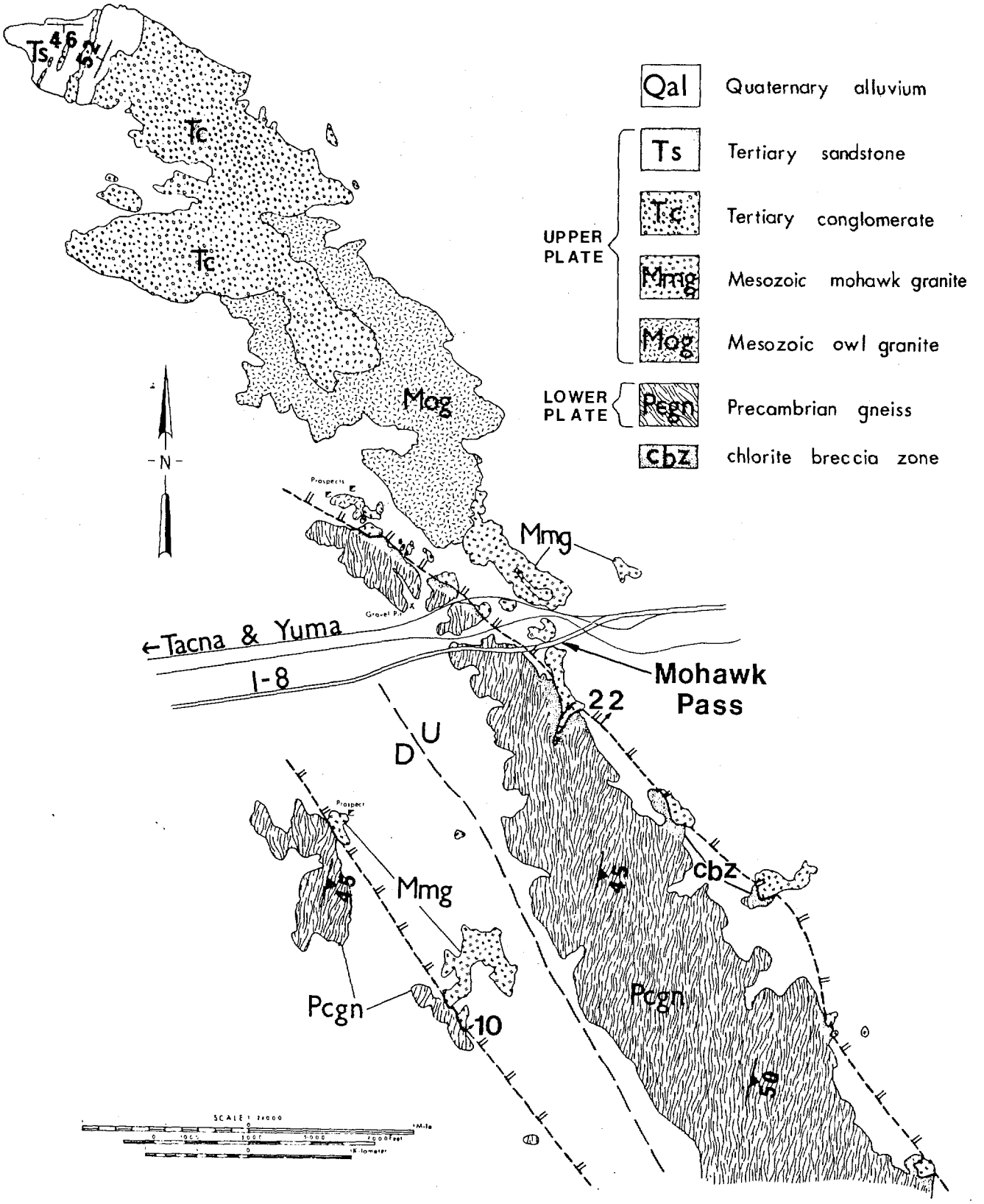

Figure 1 Geologic map of the northern Mohawk Mountains.

LITHOLOGIC UNITS

A diverse assemblage of igneous, sedimentary and metamorphic rocks is exposed in the Mohawk Mountains. South of the freeway, most of the rocks are metamorphic except for small klippen composed of a variety of igneous rocks. The majority of the igneous and sedimentary rocks crop out north of the freeway and are contained within the upper plate. Only a single small body of lower-plate, metamorphic rock exists north of Interstate 8 on the western side of the range adjacent to the abandoned town of Owl Station.

The upper-plate rocks are composed of a variety of igneous and sedimentary units. The oldest igneous rock is composed of a dark hornblende-biotite granite which has been named the Owl Station granite. This unit was intruded by a leucocratic biotite granite that varies in color from bright red to white, depending on the amount of hematite staining and weathering present. This lighter intrusion has been termed the Mohawk granite. Both of these granitic rocks are extensively fractured and faulted, giving them a blocky, crumbly appearance. These plutonic rocks are depositionally overlain by a sequence of debris flows and conglomerates (Fig. 2), which are in turn overlain by, and interbedded with, a section of arkosic sandstone. The thickness of the combined sedimentary units is only apparent because of the intense deformation of the units. However, the exposed thickness of rock, without structural correction, is approximately 300 m. In their initial work with similiar rocks in the adjacent Baker Peaks area, Pridmore and Craig (1982) consider this package of sediments to be derived from the south from a regional high. According to their model, sedimentary transport of these sediments was northward towards the Gila trough of Eberly and Stanley (1978). The large size (up to 6m) and angularity of the clasts within the debris flows and conglomerates (Fig. 2) in the Mohawks seem to indicate very minor transport of the sediments. Just as in the Baker Peaks area (Pridmore and Craig, 1982), the sedimentary units in the Mohawks have a pronounced absence of volcanic clasts or flow units, even though thick sequences of volcanic units occur just north of the range in the Castle Dome, Kofa, Tank, and Muggins Mountains. All these ranges are on the opposite side of the Gila Trough of Eberly and Stanley (1978) as the Mohawks and Baker Peaks area.

Below the detachment fault is a very distinctive package of heterogeneous gneiss, whose upper boundary is well defined by an intense zone of cataclasis and mineralization below and adjacent to the detachment fault. This unit is composed of alternating bands of mafic and leucocratic minerals, which produces spectacular outcrops of highly deformed migmatitic gneiss (Fig. 3a, b). Where Interstate 8 crosses the range, the roadcuts expose excellent cross sections of this gneiss and its attendant small-scale folds, boudinage, and intrusive dikes and sills. The foliation within this unit is very well developed, and dips rather uniformly to the east and southeast. This foliation is variably disrupted near the detachment fault and is clearly truncated by the northwest-striking fault.

STRUCTURAL GEOLOGY

The major structural feature of the Mohawk Mountains is the local expression of a regional, low-angle normal fault, or detachment fault (Fig.4,5).

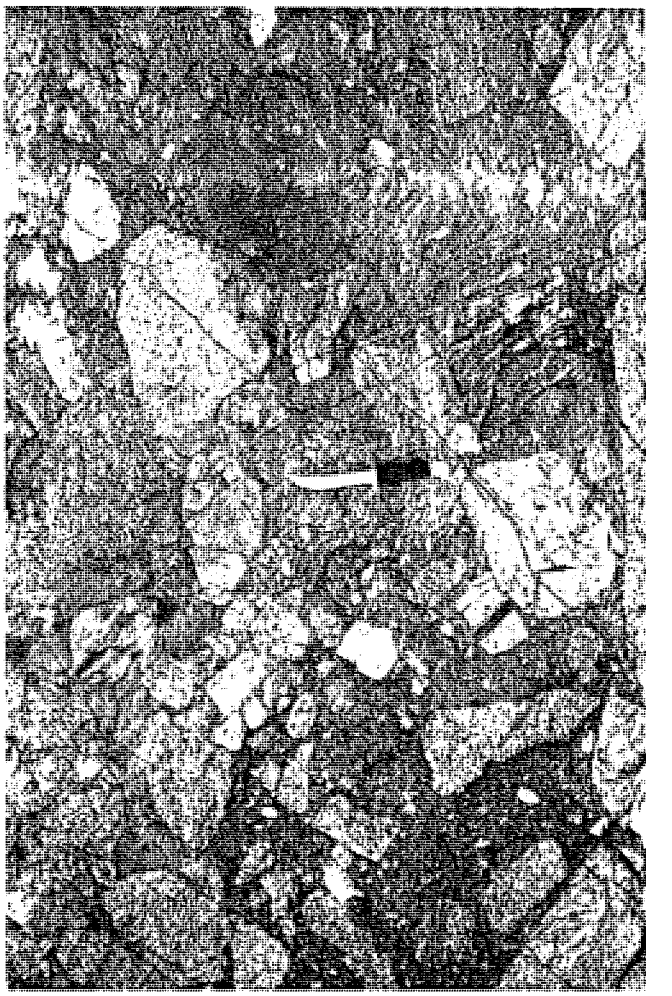

Figure 2 Upper-plate megabreccias and conglomerates north of Mohawk Pass. The majority of the clasts are composed of local granitic rocks with a few uncommon gneissic clasts. Volcanic clasts are not present. Section attains a minimum of 300m without structural correction.

This fault, inferred to be present in almost all of southwestern and central Arizona, crops out extensively along both sides of the Mohawks and is best defined by the location of klippen on the eastern side of the range (Fig. 5). This northeast-dipping fault extends from the Mohawk Pass area at least 25 km to the south on the eastern side of the range. Because access to the southern part of the Mohawks is so difficult, it is not yet known how far the fault continues to the south. The fault crosses the range at Mohawk Pass and extends north of the freeway along the western side of the range to where it passes beneath the alluvium in the Gila River area.

The fault is also exposed on the western side of the Mohawks south of the freeway. However, this geometry appears to be a product of later normal

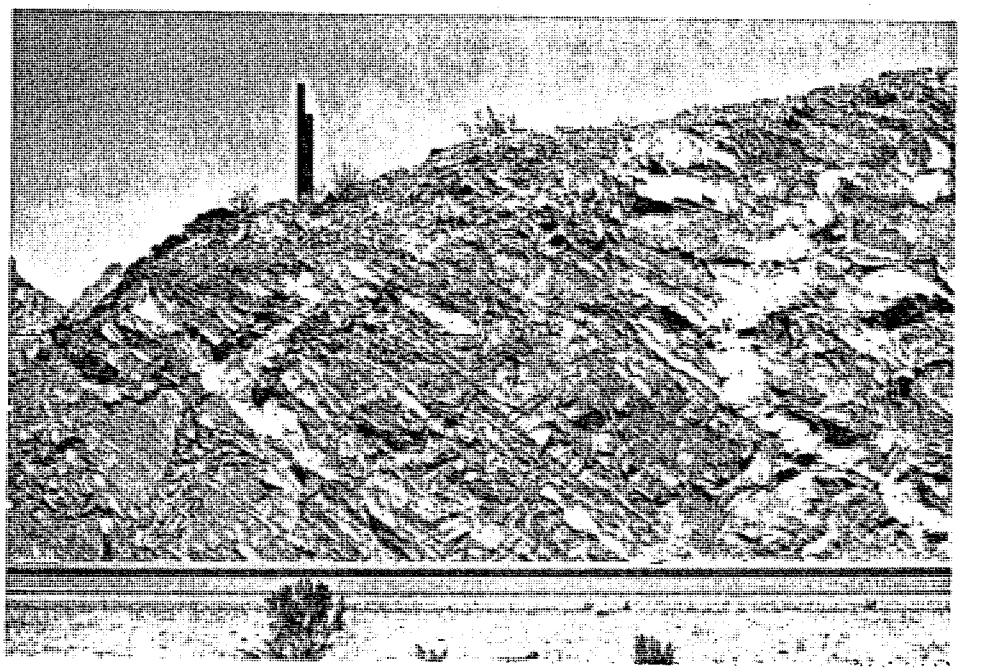

Figure 3a Lower-plate gneiss showing consistent N10E, 45SE foliation.

Figure 3b Closer view of lower-plate gneiss showing attendent small-scale folds, boudinage and differentiation of felsic and chloritic bands. Both figure 3a,b lie approximately 100m below the detachment fault.

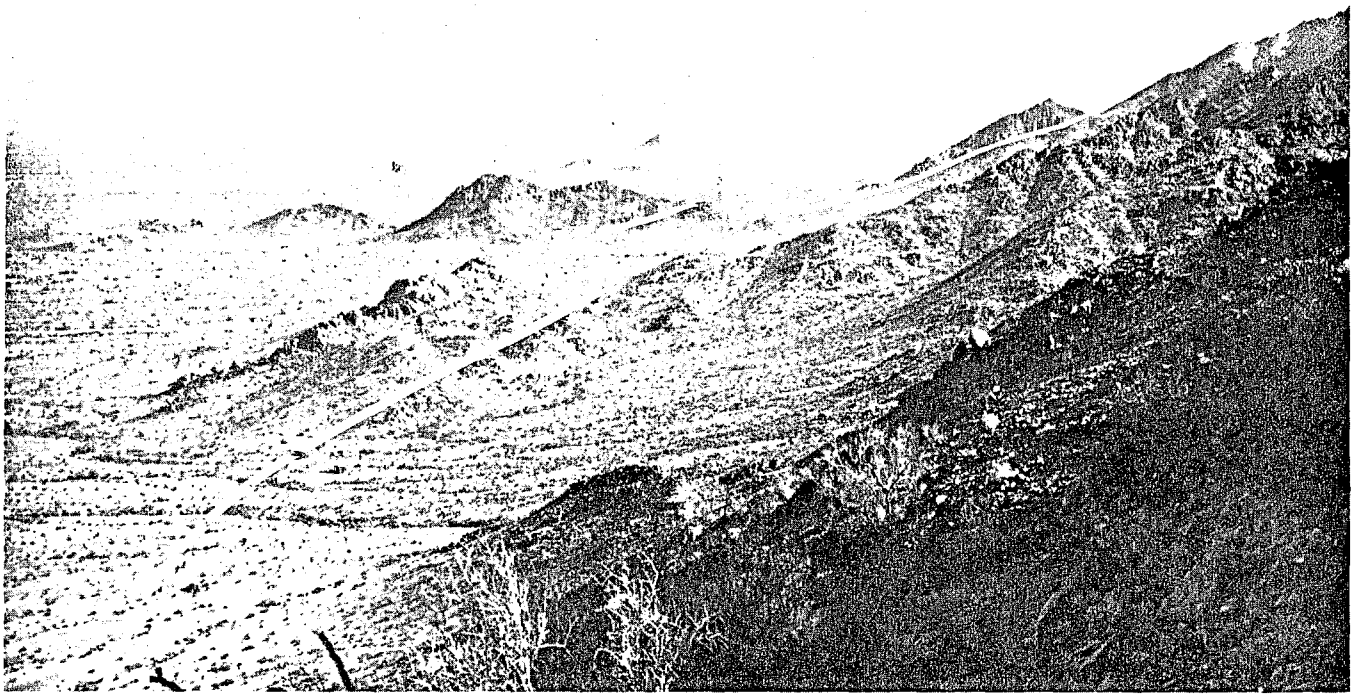

Figure 4 View of arched detachment surface looking south from Mohawk Pass along the eastern scarp of the Mohawks.

faulting that offsets the north-west dipping detachment fault. This offset appears to be approximately 950 m (Fig. 6). The dip of the fault on the western side of the Mohawks is much less than the fault in the range itself. This difference can be accomodated by post-detachment normal faults rotating the detachment fault to its present orientation.

The detachment fault itself is marked by fault gouge and rock flour in the zone adjacent to the fault. This deformation extends into the lower plate and forms a zone, approximately 1 to 10 m thick, where the gneissic lower plate has been crushed and mineralized forming a chlorite breccia zone. This zone, which is composed of gneissic fragments, is highly variable in its extent and character of deformation. In some places below the fault it is nonexistent, while in other places it forms a dark green, extremely chloritized microbreccia. In still other localities below the fault, it crops out as a light to dark green, mottled breccia with small (usually less than 5 mm in diameter), angular leucocratic rock fragments. An extensive foliation present in the lower plate is truncated at a high angle by the detachment fault, indicating that this foliation was formed before the initiation of the detachment fault.

Another important aspect of the lower plate is the conspicuous absence of a mylonitic fabric, suggesting that mylonitization is not genetically linked with detachment faulting in this portion of Arizona. Thin-section analysis of these lower plate rocks has shown minor ductile flow of quartz during metamorphism of these lower-plate rocks. However, the well developed mylonitic fabric and lineation found in the "core complex terrane" to the north and east of the Mohawks (Rehrig and Reynolds, 1980, Reynolds and Rehrig, 1980; Davis, 1980; Davis and others, 1980) is clearly not present.

Upper-Plate Structure

The extensional deformation that produced the detachment fault is clearly indicated by the geometry of the rocks in the upper plate. In the portion of the range north of Interstate 8, antithetic and synthetic faults (Fig. 7) within the upper plate are abundant and tilt the sedimentary units to varying orientations. An excellent example of this antithetic and synthetic fault system crops out in the first east-west trending ridge north of the freeway on the eastern side of the range (Fig. 8 a,b). This ridge consists of a series of

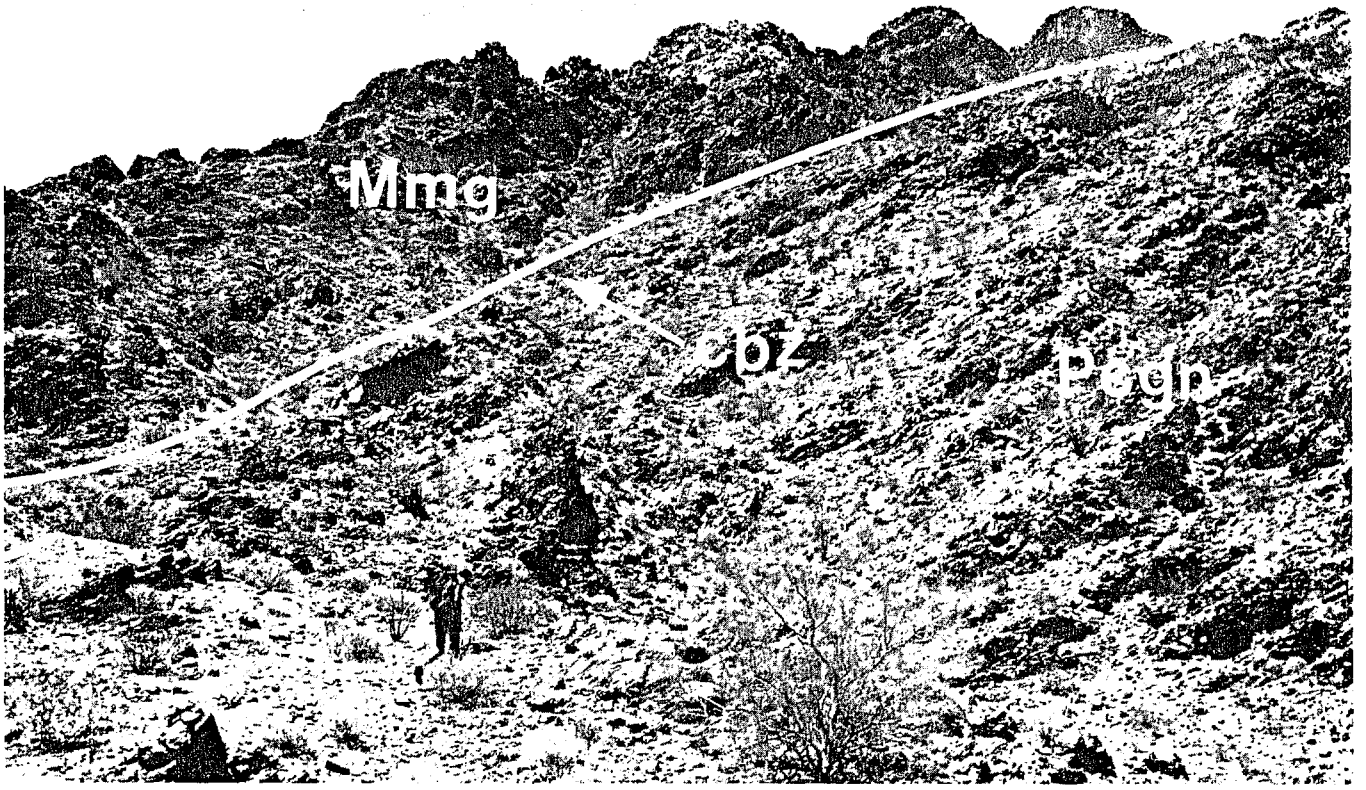

Figure 5 Close-up view of detachment surface juxtaposing upper-plate granitic rocks against lower-plate gneiss. Chlorite breccia zone below the fault varies in extent and character over a scale of meters.

small-offset antithetic faults, which impart a distinct fabric to the rock that is accentuated by erosion.

The deformation responsible for the antithetic and synthetic fault system also manifests itself in a complex array of minor fault surfaces whose orientations, striae, and sense of movement vary radically over very short distances. These minor fault surfaces have an anastomozing, intertwinning geometry much like a braided-stream pattern. These faults do not always end abruptly at the junction of an adjacent fault but often continue past nearby faults and die out in the relatively undeformed neighboring rock. The actual geometry of upper-plate extension is thus very complicated and is not approximated by simple models of listric or domino-style faulting. Similarly complex patterns of upper-plate faulting have been documented in other portions of the detachment terrane (Gross and Hillemeyer, 1982).

Numerous barite prospects and mines are present in the upper plate adjacent to the detachment fault. These mineral deposits appear to be directly related to the deformation associated with the detachment fault since the mineralization is contained in upper-plate normal faults. How, or why, the barite mineralization is related to detachment faulting is not as yet understood.

POST-DETACHMENT DEFORMATION

The detachment fault in the Mohawk Mountains appears very similar to detachment faults in other ranges such as the Whipple and Buckskin Mountains (Davis and others, 1979, 1980), except that the dip of the fault surface is more than usually seen in these other ranges. Offset of the detachment fault by later normal faults (Fig. 2) may have rotated the detachment fault to its present orientation. One such normal fault offsets the detachment fault near Mohawk Pass approximately 950 m (Fig. 2), as judged from the repetition of the detachment fault at almost pediment level on the western side of the range. Further west, the steep gravity gradient and thick valley fill (Oppenheimer and Sumner, 1980) suggest that more normal faults are present.

Rotation of the detachment fault indicates a complex history of extension in this region, probably

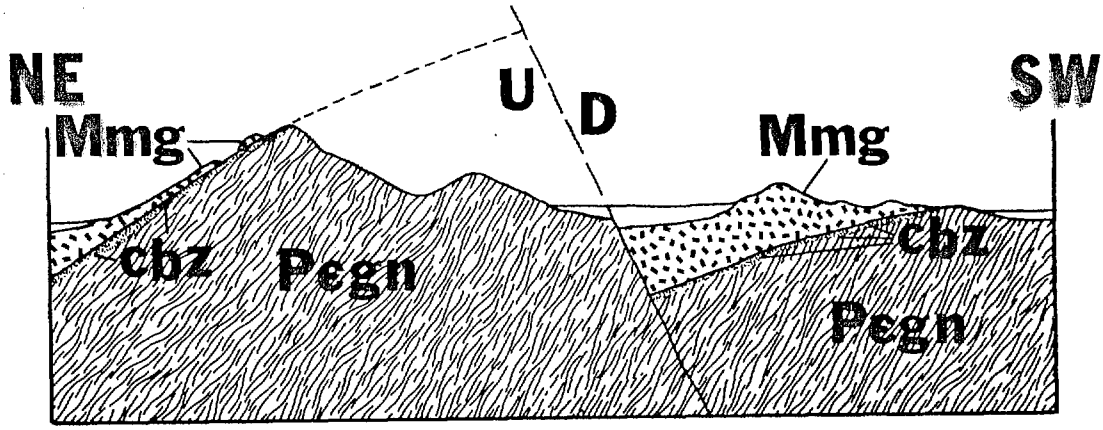

Figure 6 Diagrammatic cross section looking south from Mohawk Pass of normally faulted detachment arch with included chlorite breccia zone. Throw of the normal fault is approximately 950 m.

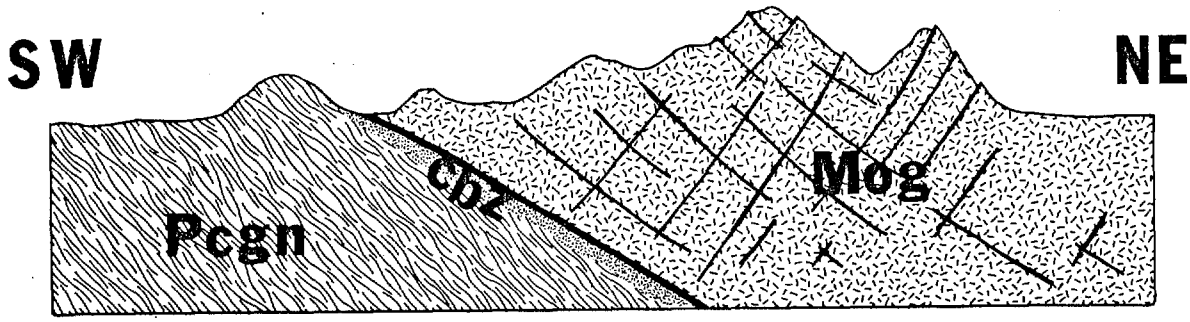

Figure 7 Diagrammatic cross section looking north from Mohawk Pass showing antithetic and synthetic fault systems associated with the detachment fault.

much like that described in the Lake Mead area by Anderson (1971, 1977, 1978) and in the Yerington district of Proffett (1977). Tilting of early-formed faults also makes it difficult to determine the original morphology of the detachment surface. How the Mohawks fit into the system of regionally developed, detachment related antiforms and synforms (Cameron and Frost, 1981; Otton and Dokka, 1981), is thus not intuitively obvious without correlation to neighboring ranges.

REGIONAL CORRELATION AND CONCLUSIONS

Detachment faulting of mid-Tertiary age has affected much of western Arizona and southeastern California. As exposed in the Mohawk Mountains of southwestern Arizona, this low-angle normal fault appears very similar to those in well known detachment terranes such as the Whipple-Buckskin-Rawhide Mountains (Shackelford, 1976, 1980; Davis and others, 1979, 1980), the Harcuvar-Harquahala Mountains (Rehrig and Reynolds, 1980), and the Santa Catalina-Rincon Mountains (Davis, 1980). The Mohawks contain a well-developed fault surface, a chlorite breccia zone, upper-plate antithetic and synthetic faults, and rotation of upper-plate crystalline and Tertiary units into the detachment fault. Lower-plate rocks appear to be devoid of the Mesozoic mylonitic fabric and lineation exposed in other ranges in Arizona and California, indicating the non-genetic relationship between mylonitization and detachment faulting (Haxel and others, 1982). Offset of the detachment fault by later normal faulting suggests that detachment faulting is just one component of the regional extension that affected this region in mid-Tertiary time.

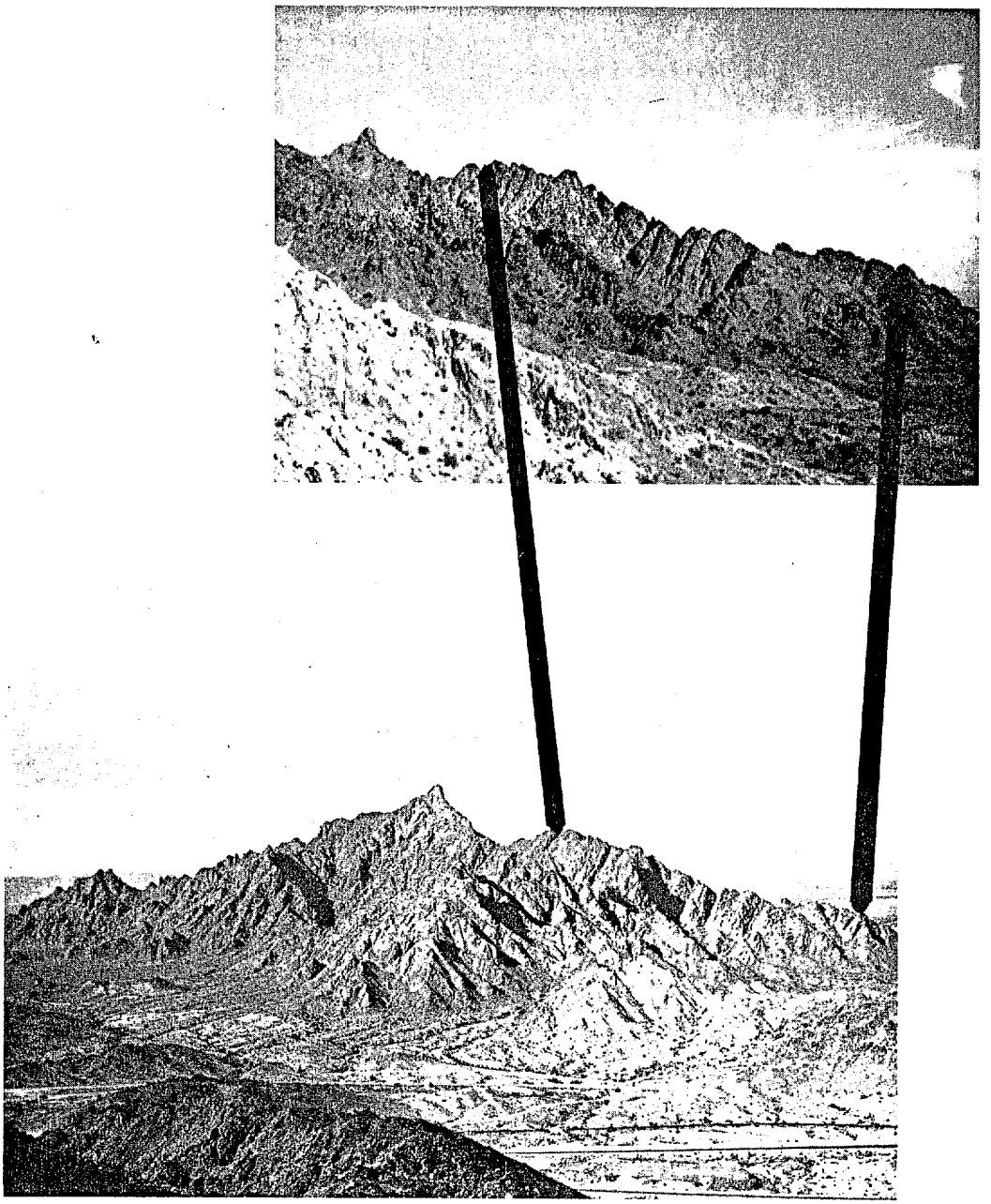

Figure 8 A, B View looking north from Mohawk Pass of antithetic fault system and detachment surface. The majority of antithetic faults in the Mohawks crop out in the first large east-west trending ridge north of I-8 on the eastern side of the range. Upper photo is an expanded view of a portion of the lower photo.

Correlation of the Mohawk detachment fault to other ranges is difficult because so little is known of this portion of southwesternmost Arizona. An extremely well-developed detachment fault is exposed in the Baker Peaks-Copper Mountains to the west (Pridmore and Craig, this volume), where a thick Tertiary redbed sequence is truncated by the fault. To the northwest, detachment faults or detachment related deformation are present in the Castle Dome Mountains (Gutman, 1981, this volume; Logan and Hirsch, this volume), Kofa Mountains (Dahm and Hankins, this volume), Trigo Mountains (Garner and others, this volume), and Midway Mountains (Berg and others, this volume). To the south, little is known about the extent of detachment faulting, although Tertiary normal faults are abundant in northern Sonora (Merriam, 1972; Gastil and Krummenacher, 1974, 1975, 1977). Determining how far south and west this style of mid-Tertiary extension continues should provide a focus for much future research in this region.

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