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0186

MINERAL EXPLORATION AT TOMBSTONE DISTRICT, ARIZONA

GEOS. 528

TERM PROJECT

BY

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Excellent job and Report!

A

THE UNIVERSITY OF ARIZONA

DEPARTMENT OF

GEOSCIENCES

FALL 1990

INTRODUCTION

Interpretation of remotely sensed images is best accomplished by conventional aerial photographic analysis techniques used with an understanding of the spectral properties of rocks and other Earth materials and their appearance on images.

Lithologic mapping from images can often be accomplished by analysis and interpretation of the spectral and spacial information within the images, as modified by the type of terrain present, its climatic environment and history, and the prevaling geomorphic processes and their stage of development.

The spectral reflectance of earth materials is often the most useful and diagnostic criterion for lithologic discrimination. Reflectance is a consequence of the chemistry and structure of the material modified by environmental factors and the physical condition of the material. For example, the majority of discernible features in the spectra of igneous rocks occurs as a result of the presence of iron, its oxidation state, and water. The same is true for sedimentary and metamorphic rocks, with the exception of carbonates, which display strong absorptions caused by vibration processes due to the CO_2 ion and Al-O-H deformation in clay materials.

The thematic mapper (TM) provides data with 30-m spatial resolution. Channels 5 and 7 of the thematic mapper are located beyond 1.0 um and are situated in spectral regions that contain characteristic features of hydrous minerals, and hence many hydrothermal altered rocks. The 1.65 um band is located where altered rocks have their highest reflectance; the 2.2 um band spans the region where hydrous minerals have a strong absorption feature. The contrast between these two bands should allow detection of rocks with hydrous minerals as one of their constituents (fig. 1).

With the help of 5/7 ratio image , lineaments directly associated with hydrothermal alterations can be easily detected to produce lineament intersections density map as shown in figure .

Band ratios are made up of the two channels divided pixel by pixel; the resulting values are then rescaled to fit the dynamic range of the photographic play back device used. The ratios exaggerate subtle color differences and subdue the effects of topography on brightness (Roman et al.,1974).

Three ratio images, 5/7, 5/1, and 4/2, are combined to create a color picture by assigning green, red , and blue colors respectively to the above mentioned individual ration images, then producing the color image by standard photographic techniques (fig. 2).

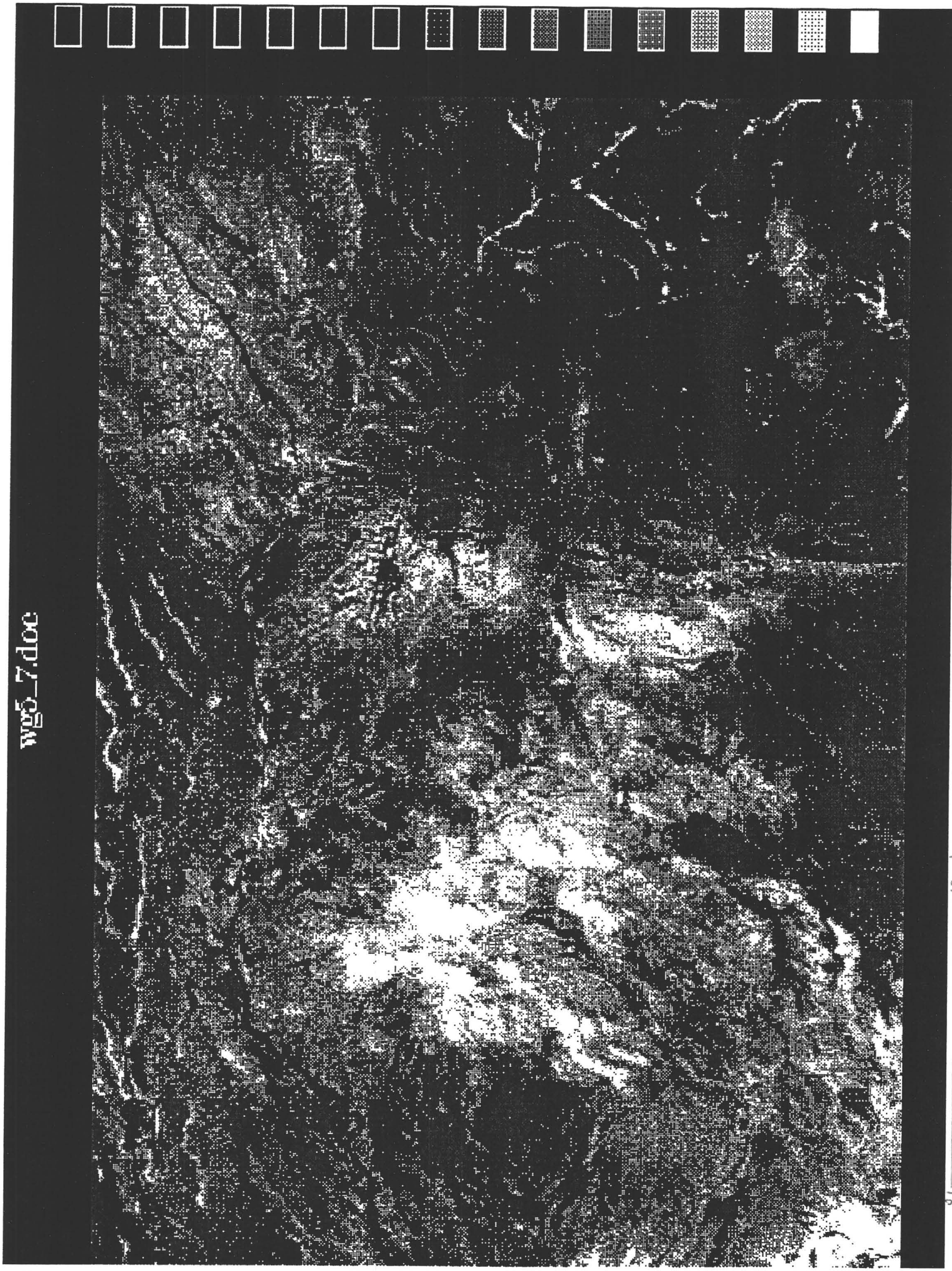


Fig. 1.

Composite ratio map (Tombstone area)

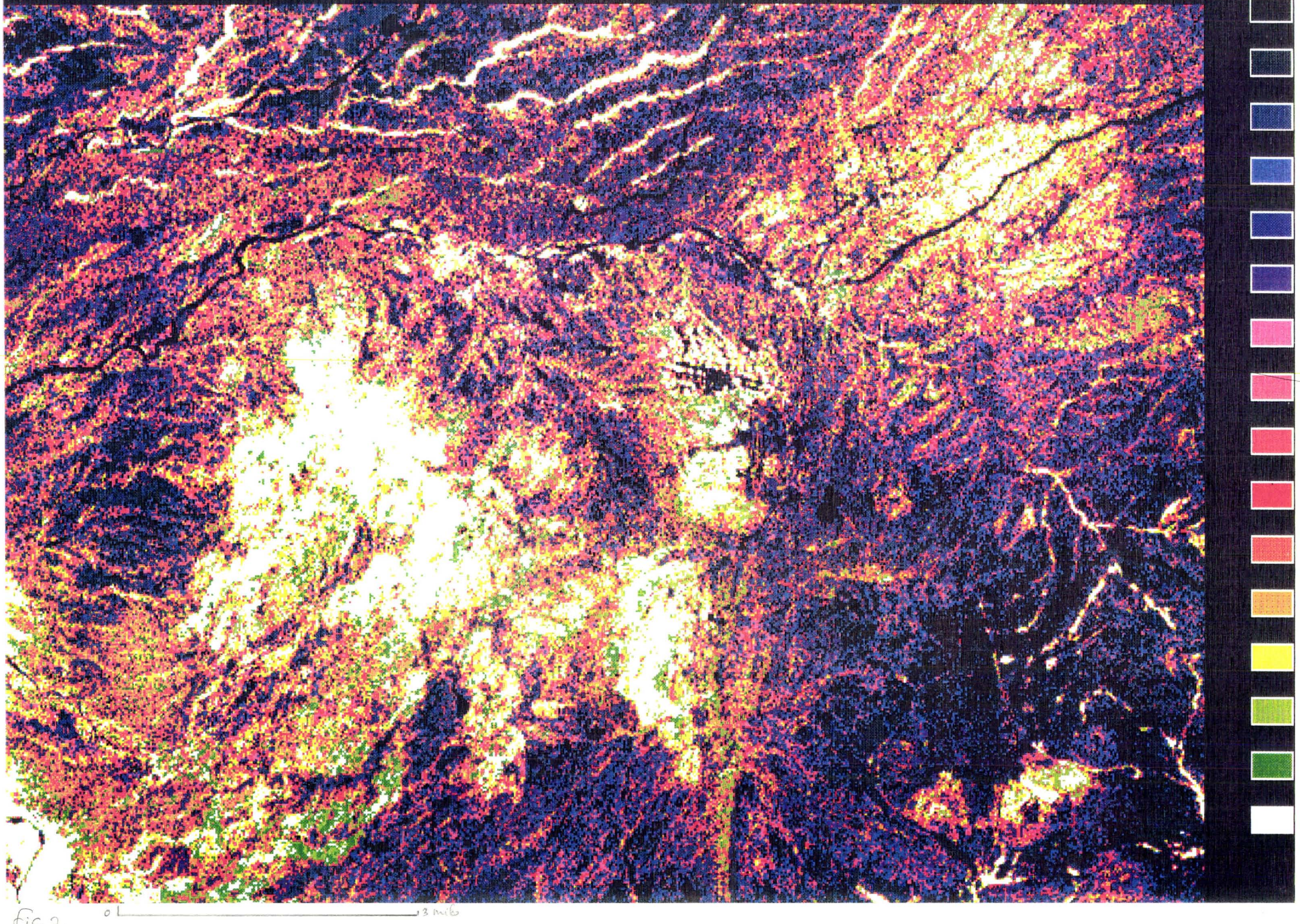


fig 2.

GEOLOGY

(After Gilluly,1956)

Rocks of the Tombstone mining district consist of schist, granite, limestone, dolomite, shale, sandstone and conglomerate of Precambrian through Mesozoic age, and younger granodiorite, tuff, rhyolite sills, plugs and dikes, andesite dikes, valley fill and a basalt plug.

Precambrian rocks, Pinal Schist and Granite, are exposed in a north-south elongated window in younger sediments and volcanic rocks in the south-central part of the district.

Overlying Precambrian rocks are 440 ft of Cambrian Bolsa Quartzite, and 844 ft of Cambrian Abrigo Limestone. Devonian Martin Limestone, 230 ft of alternating limestone and shale, unconformably overlies the Abrogo Limestone. The Missippian is represented by 786 ft of Escabrosa Limestone and dolomite.

The Pennsylvanian-Permian Naco Group is well exposed in the Tombstone Hills. Unconformably above the Naco Group is the Cretaceous Bisbee Formation .

The formation exposed at Tombstone is a much faulted and metamorphosed sequence of sandstone, shale and limestone that is 3,079 ft thick. Of considerable importance as far as mineral deposition is concerned is the lower 128 ft of the formation, which consists of the "Novaculite" unit which contains 60 ft of basal shale and limey sandstone with localized limestone conglomerate, the "Blue limestone" which is 34 ft thick, 24 ft shale and a 10-ft thick bed of limestone.

Late cretaceous igneous rocks, the Schieffelin granodiorite and the Uncle Sam quartz latite tuffs are exposed in the western and southern part of the district, and dikes of granodiorite are found throughout its central part.

Newell (1974) describes the Uncle Sam quartz latite tuff as a hypocrystalline rock that is slightly welded and contains ash-phenoclasts that are embayed and set in a devitrified matrix.

The granodiorite and tuffs are cut by dikes of hornblende andesite that are bluish gray to light olive-gray in color. They consist of medium to coarse-grained hornblende phenocrysts and fine-grained plagioclase in a microcrystalline groundmass (Newell,1974).

The youngest rock in the area is a basalt plug which intrudes the Gila Conglomerate on the east side of Walnut Gulch, north of the central part of the district.

The hornfelsic shales played a dual role: they fractured well, thus providing excellent, confined channel ways for ascending mineralizing solutions; and, because they were unshattered and competent except in the immediate vicinity of the fissure veins, they formed impermeable caps under which the solutions could spread and replace favorable limestone horizons.

The most favorable loci for ore deposition were where a northeast fissure vein, dike or premineral fault cut a favorable horizon that had been folded by one of the west-northwest trending anticlinal flexures. In most cases, the "10-foot" and "Blue" limestone were more tightly folded and fractured than were the underlying Naco limestone. These features, together with the fact that the "10-foot" and "Blue" limestones were capped and bottomed by impermeable hornfelsic shales, made them the most receptive hosts in the district.

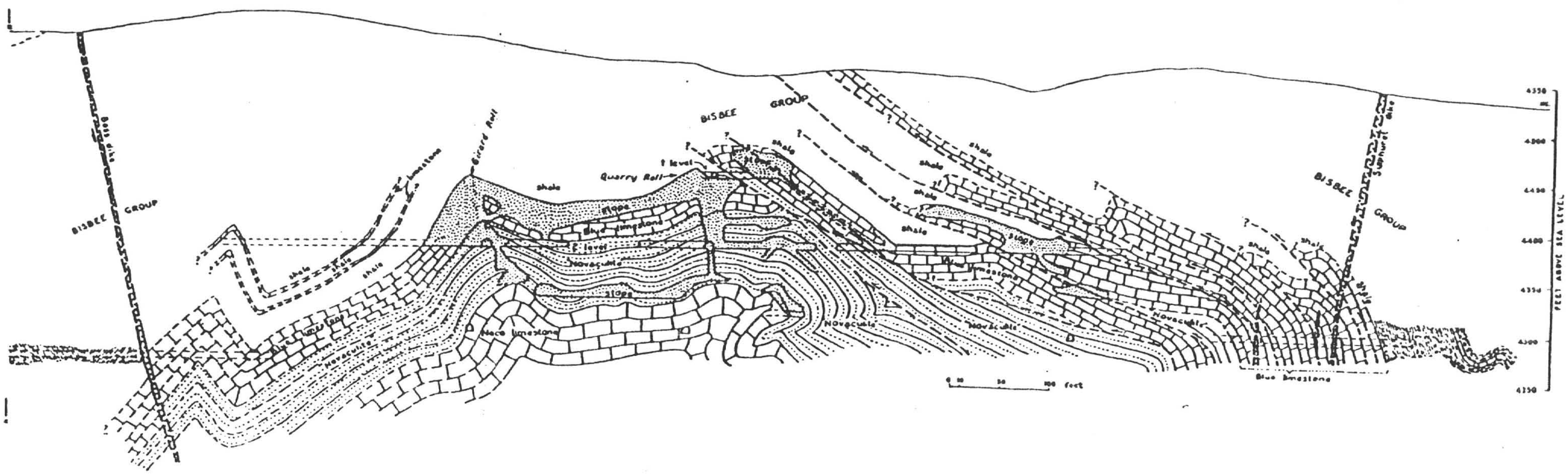


Plate XXIV, A.—Section along West Side fissure, looking northwest (northeast half; joins Plate XXIV, B at line X-X).

fig. 3

Butler, B.S. & Wilson, E.D., 1938

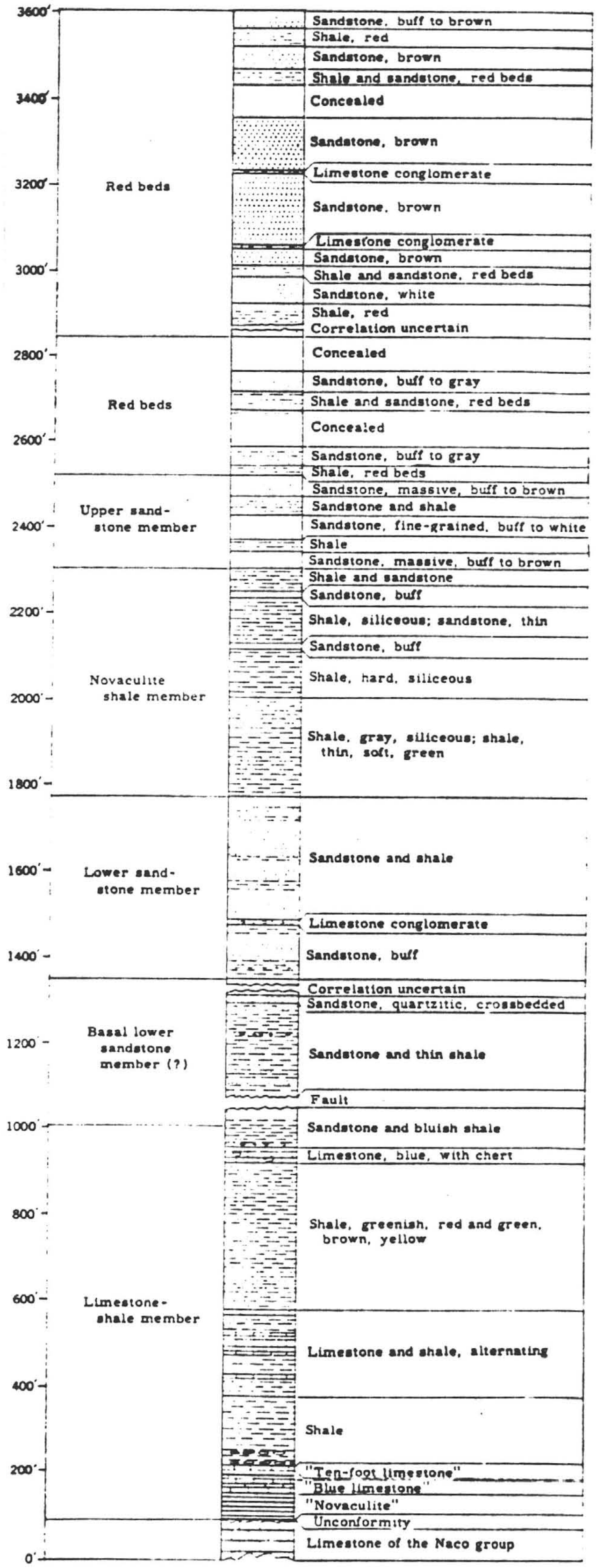


FIGURE 5.—Composite section of the Bisbee formation in the Tombstone mining district. After Lyden, O'Donnell, Hernon, and Higdon (unpublished mine rept., 1937).

Explanation

Geology

QTgu — OLDER OR UNDIFFERENTIATED SURFICAL DEPOSITS (HOLOCENE TO OLIGOCENE):—Gravel, sand, and silt (Pleistocene and Pliocene—Mainly alluvium of basins; includes some colluvium and landslide deposits. Generally light-pinkish gray, weakly indurated, and with poorly rounded clasts; locally well indurated. Thickness several meters to hundreds of meters.

QTb — Basalt (Pleistocene to Pliocene)—Lava flows, pyroclastic rocks, and some intercalated gravel. Thickness several meters to a few hundred meters in most places. Radiometrically dated at 0.25, 1.0, and 3.2 m.y. old

Tva — Extensive andesite and dacite (Miocene and Upper Oligocene)—Lava flows, pyroclastic rocks, some intercalated epiclastic rocks, and dikes. Mostly gray, fine-grained, porphyritic rocks; includes some very coarse feldspar porphyry andesite (Turkey track porphyry, an informal term of Cooper, 1961). Thickness mostly several meters to several tens of meters. Dated at 24, 25, 27, 33, and 39 m.y.

Tv — Extrusive rhyolite and rhyodacite (Miocene and Upper Oligocene—Lava flows, welded tuff, pyroclastic rocks, and some intercalated epiclastic rocks. Light-gray to grayish-pink, vitric to fine-grained, porphyritic. Commonly a few tens to a few thousand of meters thick. Dated at 23, 24, 25, 26, 26, 26, and 27 m.y. An additional date of 47 m.y., if substantiated, may indicate the presence of Eocene rocks in the lower member of the S O Volcanics of Cochise Co.

Tlc — Lower conglomerate, gravel, and sand (Oligocene and Eocene?)—Alluvium; commonly grayish-red deposits of small, well rounded, nonvolcanic clasts. Mostly several meters to a few tens of meters thick.

Tlv — UPPER CORDILLERAN (LARAMIDE) IGNEOUS ROCKS (LOWER PALEOCENE):—Lower volcanic rocks—Rhyolite to andesite lava flows, pyroclastic rocks, and some intercalated epiclastic rocks. Dated at 57 m.y. Possibly younger age to east.

TKg — MAIN CORDILLERAN (LARAMIDE) IGNEOUS ROCKS:—Porphyritic and aplitic intrusive rocks (Paleocene and Upper Cretaceous)—Mostly latitic porphyry to dacitic porphyry in small stocks and plugs and aplitic bodies not associated with other granitoid stocks. Dated at 61, 63, 63, 64, and 65 m.y.

Kib — Fluidized intrusive breccia – exact age unknown, but penetrates, and thus younger than Uncle Sam porphyry.

Kr — Rhyodacite tuff and welded tuff.—Includes parts of Salero Formation, Sugarloaf Quartz Latite, and Bronco Volcanics, and all of Red Bay Rhyolite, Cat Mountain Rhyolite of Brown (1939) and Uncle Sam Prophyry. Includes local intrusive bodies and locally contains fragments of exotic rocks. Thickness commonly several tens of meters to several hundreds of meters. Dated at 66(?), 70, 72, 73, and 73 m.y. The Uncle Sam, in the Tombstone area, is dated 72 m.y.

Ka — Andesitic to dacitic volcanic breccia.—Includes parts of Solero Formation, Sugarloaf Quartz Latite, and Bronco Volcanics, and all of Demetrie Volcanics and Silverbell Formation of Courtright (1958). Commonly contains large blocks of exotic rocks and locally includes some sedimentary rocks and intrusive rocks. Several tens of meters to several hundreds of meters thick in most places.

Klq — Lower quartz monzonite and graodiorite—Includes some quartz diorite; appears in small stocks. Locally associated with mineralization. Dated at 70, 71, 72, 73, 74, 74, 74, and 76 m.y. The Schieffin granodorite at Tombstone is 72 m.y.

Kb — BISBEE FORMATION OR GROUP, UNDIFFERENTIATED (LOWER CRETACEOUS):—Upper part of Bisbee Formation or Group, undifferentiated, and related rocks.—Includes upper part of Bisbee Formation, Mural Limestone, Monta, Cintura, Willow Canyon, Apache Canyon, Shellenberger Canyon and Turney Ranch Formations (not listed in stratigraphic sequence) of the Bisbee Group, Amole Arkose of Bryant and Kinnison (1954), and Angelic Arkose. Consists of brownish- to reddish-arkose, gray siltstone, sandstone, conglomerate, and some fossiliferous gray limestone. Commonly several hundred meters thick

Jg — GRANITE AND QUARTZ MONZONITE (JURASSIC)—Stocks of pinkish-gray coarse-grained rock. Locally associated with mineralization. Dated at 140, 148, 149, 149, 150, 153, 160, 161, 167, 178, 185 m.y.

PIPs — Sedimentary rocks (Lower Permian and Upper Pennsylvanian)—consists of Epitaph Dolomite (Lower Permian), Colina Limestone (Lower Permian), and Earp Formation (Lower Permian and Upper Pennsylvanian), undifferentiated. Epitaph Dolomite is a dark- to light-gray slightly cherty dolomite, limestone, marl, siltstone, and gypsum, 120-280 meters thick. Colina Limestone is a medium gray, thick-bedded, sparsely cherty, and sparsely fossiliferous limestone 120-280 meters thick. Earp Formation is a pale-red siltstone, mudstone, shale, and limestone, 120-240 meters thick.

IPh — Horquilla Limestone (Upper and Middle Pennsylvanian)—Light-pinkish-gray, thick- to thin-bedded, cherty, fossiliferous limestone and intercalated pale-brown to pale-reddish-gray siltstone that increases in abundance upward. Typically 300-490 meters thick.

MDs — SEDIMENTARY ROCKS (MISSISSIPPIAN AND DEVONIAN)—Consists mainly of Escabrosa Limestone (Mississippian)—locally (Armstrong and Silberman, 1974) called Escabrosa Group—and Martin Formation (Upper Devonian), undifferentiated. In part of the Chiricahua Mountains also includes Paradise Formation (Upper Mississippian) and Portal Formation of Sabins, 1957a (Upper Devonian). In the Little Dragoon Mountains and some adjacent hills also includes Black Prince Limestone, whose fauna and correlation show strongest affinities with Mississippian rocks but which may include some Pennsylvanian rocks. Escabrosa Limestone is a medium-gray, massive to thick-bedded, commonly crinoidal, cherty, fossiliferous limestone 90-310 meters thick. Martin Formation is thick- to thin-bedded, gray to brown dolomite, gray sparsely fossiliferous, and some siltstone and sandstone, 90-120 meters thick. Paradise Formation is a brown, fossiliferous, shaly limestone. Portal Formation is a black shale and limestone 6-105 meters thick. Black Prince Limestone is pinkish-gray limestone with a basal shale and chert conglomerate, as much as 52 meters thick.

OCs — SEDIMENTARY ROCKS (LOWER ORDOVICIAN TO MIDDLE CAMBRIAN):—El Paso Limestone (Lower Ordovician and Upper Cambrian), Abrigo Formation (Upper and Middle Cambrian), and Bolsa Quartz (Middle Cambrian), undifferentiated.—El Paso Limestone is a gray, thin-bedded cherty limestone and dolomite 90 meters to about 220 meters thick. Abrigo Formation is a brown, thin-bedded fossiliferous limestone, sandstone, quartzite, and shale, 210-240 meters thick. Bolsa Quartzite is a brown to white or purplish-gray, thick-bedded, coarse-grained quartzite and sandstone with a basal conglomerate, 90-180 meters thick. To the east, equivalents of part of the Abrigo Formation and Bolsa Quartzite are known as the Coronado Sandstone.

Cs — Sedimentary rocks (Upper and Middle Cambrian)—Abrigo Formation (Upper and Middle Cambrian), and Bolsa Quartzite (Middle Cambrian), undifferentiated.

Yg — GRANITOID ROCKS (PRECAMBRIAN Y):—Mainly granodiorite and quartz monsonite, unfoliated to foliated, in part metamorphosed. Generally in stocks, which ahve been little studied.

Xp — PINAL SCHIST (PRECAMBRIAN X)—Chlorite schist, phyllite, and some metavolcanic rocks. metavolcanic rocks, metaquartzite, metaquartzite conglomerate, and gneiss. One metavolcanic rock dated at 1715 m.y.

CONTACT—Dotted where concealed.

MARKER HORIZON—Dotted where concealed.

DIKES—Showing dip.

70 — FAULTS—Showing dip. Dotted where concealed or intruded; ball and bar on downthrown side.

45 — Normal

45 — Reverse

Strike-slip—Arrow couple shows relative displacement. Single arrow shows movement of active block.

Major thrust fault—Sawteeth on upper plate.

Thrust fault—Sawteeth on upper plate.

Anticline.

Syncline.

30 — Inclined strike and dip of beds.

EXOTIC BLOCK BRECCIA—Rock contains chip or block inclusions of rock different from those of host or other blocks nearby. Typically of volcanic-tectonic or sedimentary-tectonic origin; excludes Tertiary megabreccia deposits.

(QTgu) 157 — Site of well or generalized site of several wells, showing unit penetrated, if known, and depth of well, in feet. 100 feet equals 30.5 meters.

72x — COLLECTION SITE—Radiogenically dated rock showing age in millions of years. Query before symbol where precise location uncertain.

Roads and Highways

Dry wash

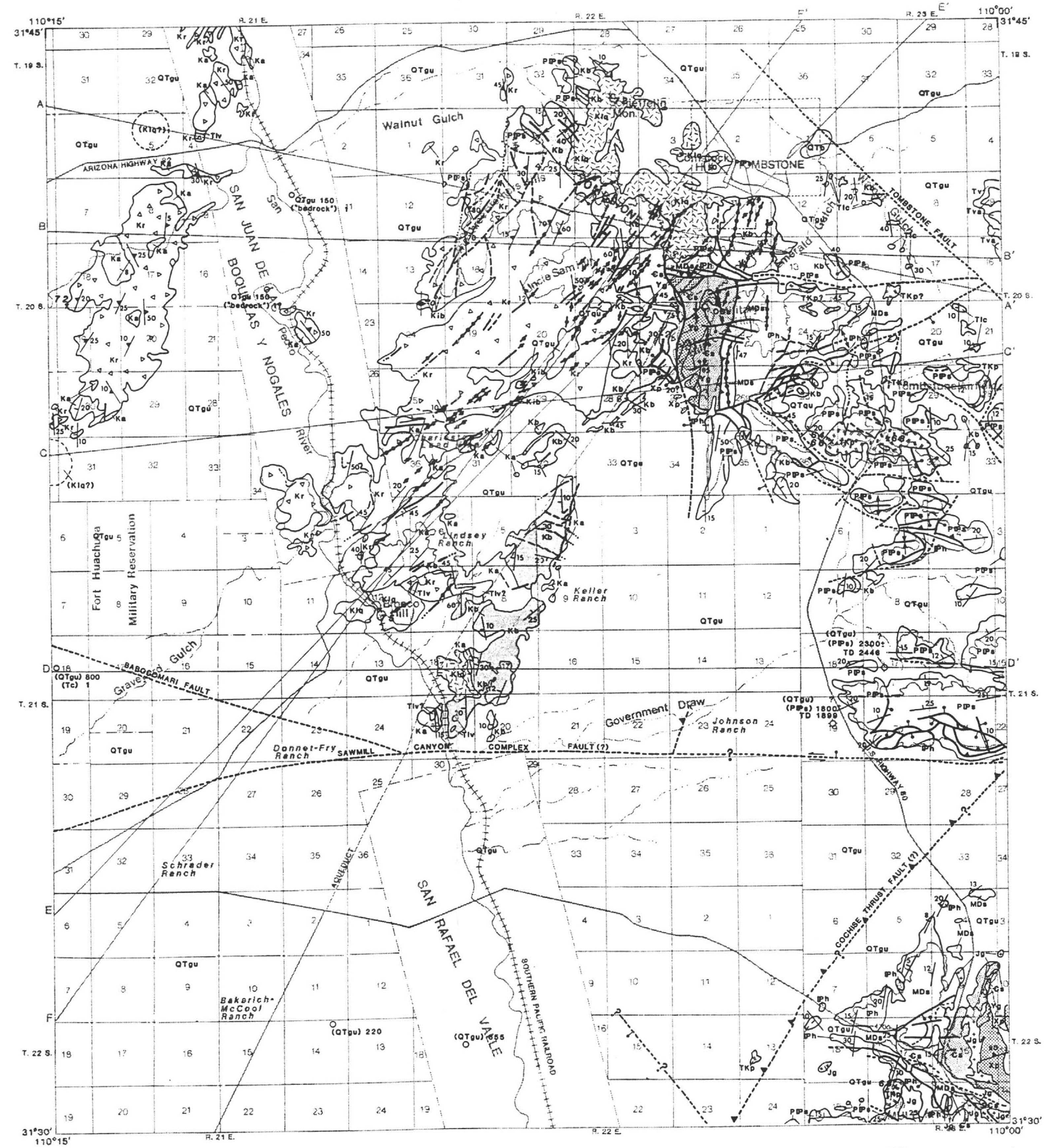
Southern Pacific Railroad

Government Reservation Boundary

Aqueduct

A—A' Cross section line

Briscoe, J.A. et al., 1982



Tombstone Development Company, Inc.
Tombstone, Arizona

Geology adopted from Drewes, Harold, 1980, and Newell, R.A., 1973.

By James A. Briscoe
James A. Briscoe and Associates
Tucson, Arizona

1 0 1 2 3 Miles

N

Figure 3. Generalized geological and structural map on screened topographic base.

Reconnaissance mapping by remote sensing is cost-effective and time-efficient. Lithologic contacts can be extended over large areas with a minimim of ground control, and identification of rocks types can be extrapolated on the basis of spectral and geomorphic information.

In general though, maps made from remotely sensed images are not as accurate as those produced by conventional field mapping. In contrast, a reconnaisance photo-interpretation map depicts "telegeologic" units which are similar-appearing units in the images, representing bedrock and associated soil and vegetation cover.

Figure , show unsupervised classification using an automatic clustering algorithm that analyses the "unknown" pixels in the data base and divides them into 16 spectrally distinct classes based upon their natural groupings in 7 spectral dimensions.


classified wgtm.lan (7 bands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
3 miles

fig. 4.

Fig. (4)

Legend discription:

1- Bisbee formation or group Undifferentiated (Lower Cretaceous).

2- Buildings

4- Rhyodacite tuff

12, 13 & 14 - Sedimentary rocks (Lower Permian and Upper Pennsylvanian) and (Upper and Middle Cambrian).

15 and 16 - Undifferentiated deposits (Holocene to Oligocene)

STUDY OF LINEAR FEATURES:

The study of linear features in images and photohraphs is the study of structural geology, as most of these features represent the surface expression of faults, joints, folds, lithologic contacts, or other geologic discontinuities, all of which are clues of the internal geometry of the lithosphere. Lineament studies of continental masses have generally presumed mineral deposits to be related to crustal features, or zones of weakness, which have provided pathways for mineralizing agents to rise from a general source in the lower crust or upper mantle and form deposits wherever the host conditions were propitious.

As linear features shown on remote sensing imagery of increasingly smaller scale [greater extent] reflect increasingly more funtamental structures, their study will provide insights not only to the location of ore bodies and mineralized districts, but also to metallogenic theories as well.

Structural features of the Tombstone district in Southeastern Arizona have had a marked effect on the location of ore bodies. A set of fractures trending northeast provided the channels through which the hypogene ore solutions moved upward. Ore minerals were precipitated other structures that provided opening or intersected beds favorable to replacement.

Four groups of deposits classified on a structural basis are recognized (Butter,B.S.&Wilson,E.D.(1938):

1) Those associated with dike fissures trending north;
2) Those associated with faultes;
3) Those in anticlines and "rolls"; and
4) Those with no obvious control other than fissures trending northeast.

Linear features at Tombstone are useful in defining the above mentioned target areas- local settings in which ore bodies may be concentrated and which merit more detailed study in the field.

The lineament intersections were counted for the entire area on a mile- by mile grid and their density was contoured (Fig. 5). Lineament density contouring is a technique for enhancing regional structural trends while minimizing interpretation biases due to analyst subjectivity, cultural features, etc. (Sawatzky and Raines, 1982).

The highest density of lineaments is found south west~~ern~~ of Tombstone. Increased fault density, or intersections of structural zones, may be favorable loci for intrusion of (mineralizing) magmas. The lineament density map, combined with acillary geologic , geobotanical (fig. 6) and geophysical data , would focus further interest in this area.

The distribution pattern of mo~~l~~lybdenum in mesquite trees shows almost the same pattern and trend surface of the lineament intersections density map. The mobility of copper and zinc explain the slight deviation in the general pattern. The NW-SE is well defined in Mo, Ag, Zn, and Cu while Mo and Zn distributions clearly preserve the NE-SW trend direction.

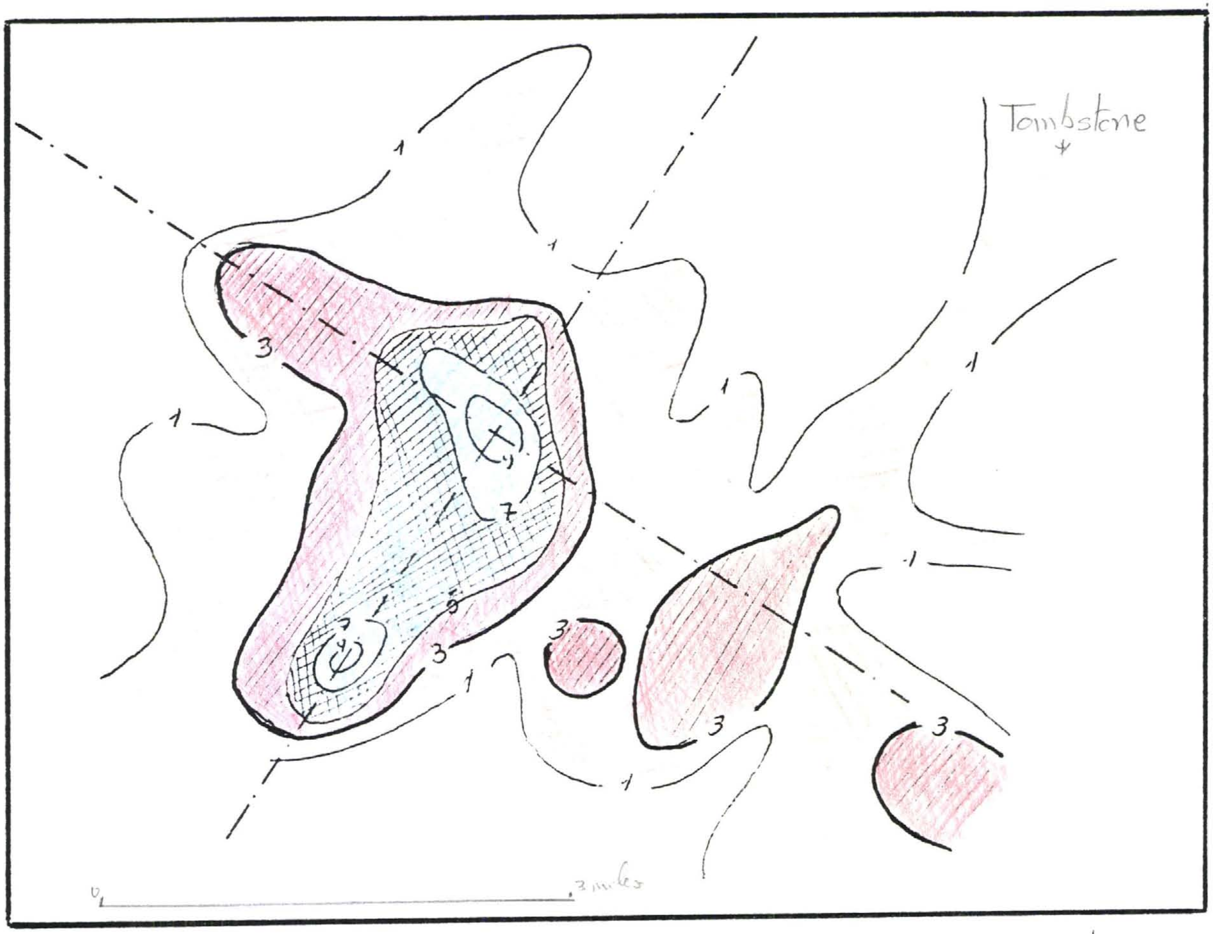


Fig. 5 Contour map of lineament intersections density.
Contour interval is 2 intersections per unit area.

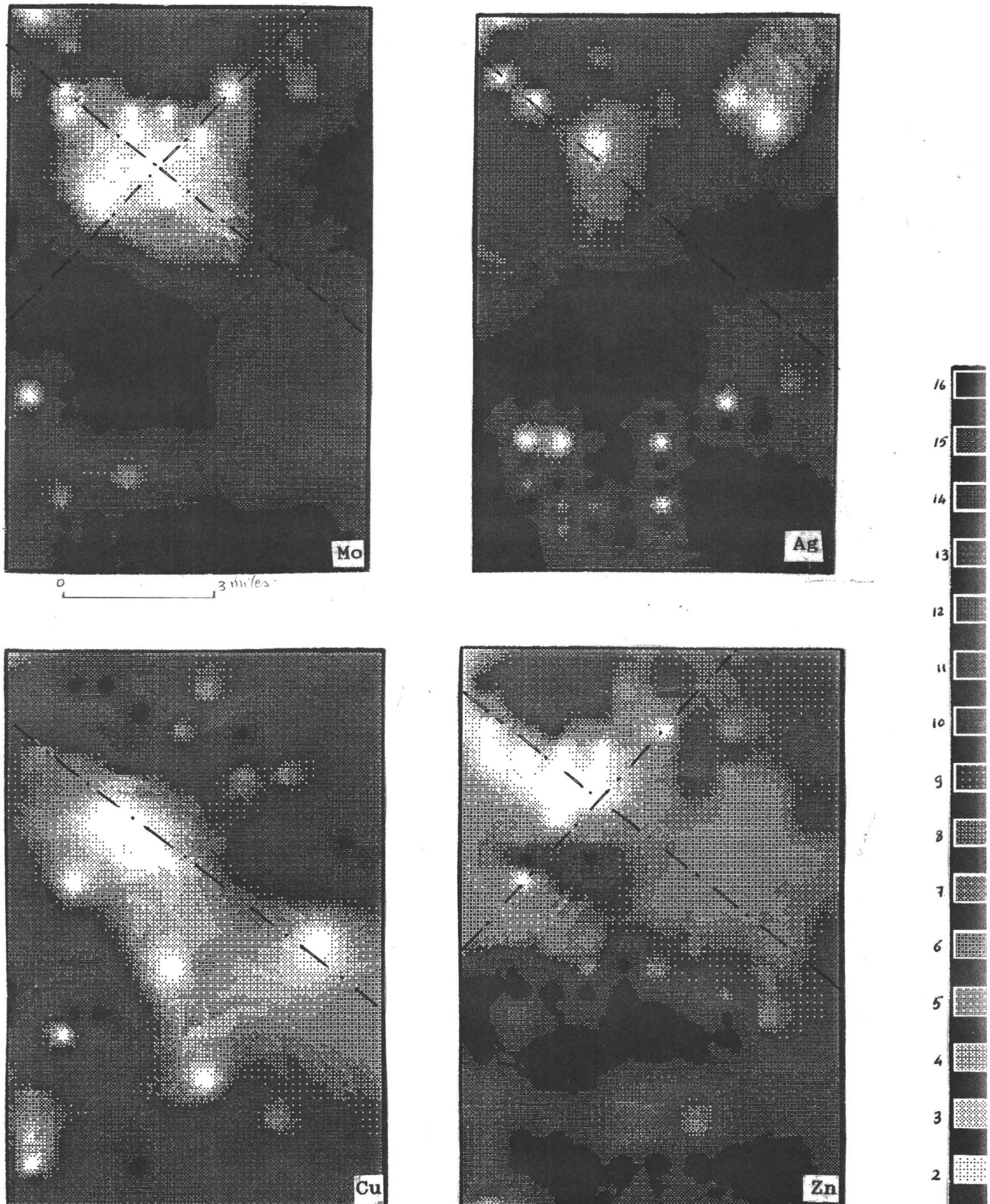


Fig. 6 Distribution patterns of Mo, Ag, Cu, and Zn in mesquite trees. Tombstone, Arizona. Modified from Newell, R.A., 1973 and Briscoe, J.A., 1988.

Fig (6)

Legend Discription:

Ag:	1=3 ppm	and 15=1 ppm	interval=0.133 ppm
Zinc:	1=800 ppm	and 15=400 ppm	interval=26.6 ppm
Cu:	1=200 ppm	and 15=100 ppm	interval=6.66 ppm
Mo:	1=14 ppm	and 15=5 ppm	interval=0.6 ppm

PRINCIPAL COMPONENT ANALYSIS

A principle component analysis is concerned with explaining the variance-covariance structure through a few linear combinations of the original variables. Its general objectives are (1) data reduction, and (2) interpretation.

An analysis of principal components often reveals relationships that were not previously suspected and thereby allows interpretations that would not ordinarily result.

Analyses of principal components are more of a means to an end rather than an end in themselves because they frequently serve as intermediate steps in much larger investigations. For example, principle components may be inputs to a multiple regression or cluster analysis. Moreover, (scaled) principal component are one "factoring" of covariance matrix for factor analysis models. These investigations will be considered in future reseach.

Principal components analysis are applied to all seven subset channels composing a multispectral data set. The number of components produced are equal to the number of channels being analyzed. The largest percentage of the total scene variance are included in the first principle component (PC1), with the lower-order components (PCs 2,3,....&7) each containing a smaller percentage of the total variance. The lowest-order, or last component, tends to be dominated by undesirable noise. Thus, the first five principal components contain nearly all the effective information existing in the original four bands, and the last components can be neglected. In this situation, when the transformed pixel values are converted to film format for photographic displays, PCs 1,2,....,&5 are analyzed as single black-and white images (fig. 8) or the first three component images are combined to form a color composite (fig. 9). In digital domain, the three components can be used as input to automatic image classification algorithms. The geologic applications of Landsat MSS principal component images are described by Blodget et al.,(1978), Santisteban and Munoz (1978), and Williams (1983).

The Composite image of the 1st three PC bands enhance the NW-SE trend fault with a clear displacement (Fig. 7). That fault intersect the geobotanical and structural anomalies as shown in figure 6 & 16 .

The eigenvector of the first principal component (PC1) contains nearly equal loadings of the seven TM bands and accounts for nearly 79.78 percent of the total scene variance. Principal component two (PC2) accounting for 10.74 percent of the total scene variance, contains more positive loadings of landsat TM bands 1,2,3 &6 contrasted against a less negative loading of TM band 4,5 &7. Basically, this component contrast TM bands 1,2,3 & 6 against TM bands 4,5,&7, and suggest that materials showing strong contrasts between these two pairs of bands, will be emphasized in the resultant image. The materials that exhibit the strongest contrast will show the greatest separation in gray shades on the image. The positive-negative relationship of the first two components (PC1 & PC2), a common charcteristic of this transformation, express the uncorrelated nature of the new coordinates. The third component (PC3) determine the biomass content and delineation of high moisture body. the fifth component (PC5) enhance the main dykes and ridges in the area.

PRINCIPAL COMPOMENTS:

COVARIANCE MATRIX:

	1	2	3	4	5	6	7
1-	97.964	46.220	66.519	30.783	76.179	14.385	62.553
2-	46.220	34.827	58.025	33.090	73.655	10.796	52.320
3-	66.519	58.025	114.115	67.787	**157.692**	23.121	**105.836**
4-	30.783	33.090	67.787	65.532	**109.407**	11.185	60.651
5-	76.179	73.655	**157.692**	**109.407**	310.292	38.420	**186.922**
6-	14.385	10.796	23.121	11.185	38.420	20.993	28.186
7-	62.553	52.320	**105.836**	60.651	**186.922**	28.186	131.051

	EIGENVALUES:	VAR.%	TOTAL %	ANGLE	SCALE
1-	618.205	79.781	79.781	37.320	1.709
2-	83.220	10.740	90.521	77.909	4.659
3-	33.792	4.361	94.882	92.857	7.311
4-	18.153	2.343	97.225	80.153	9.975
5-	13.288	1.715	98.940	57.522	11.659
6-	6.194	0.799	99.739	92.487	17.076
7-	2.022	0.261	100.000	87.623	29.885

EIGENVECTORS:

	1	2	3	4	5	6	7
1-	0.241	**0.835**	-0.157	-0.397	0.181	-0.001	-0.174
2-	0.202	0.274	0.162	0.168	-0.169	-0.124	**0.886**
3-	0.401	0.190	0.328	**0.555**	-0.317	-0.329	-0.422
4-	0.261	-0.085	**0.764**	-0.164	0.337	0.448	-0.015
5-	**0.685**	-0.427	-0.174	-0.395	0.086	-0.390	0.045
6-	0.095	0.013	-0.226	0.519	**0.812**	-0.087	0.060
7-	0.441	-0.042	-0.420	0.233	-0.240	**0.718**	0.000

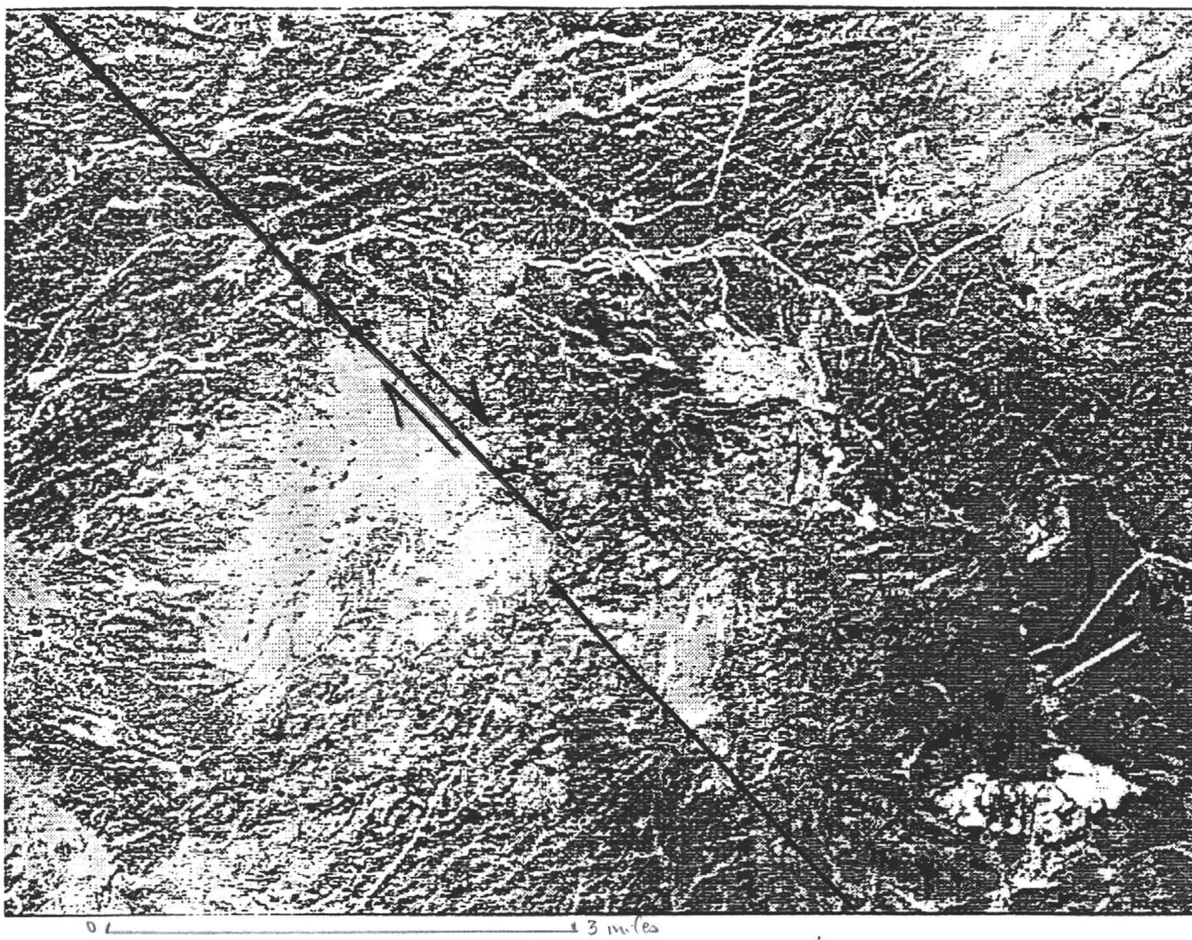


Fig. 7 Composite image of the 1st three Principal component bands enhnce the NW-SE trend fault.

PC1

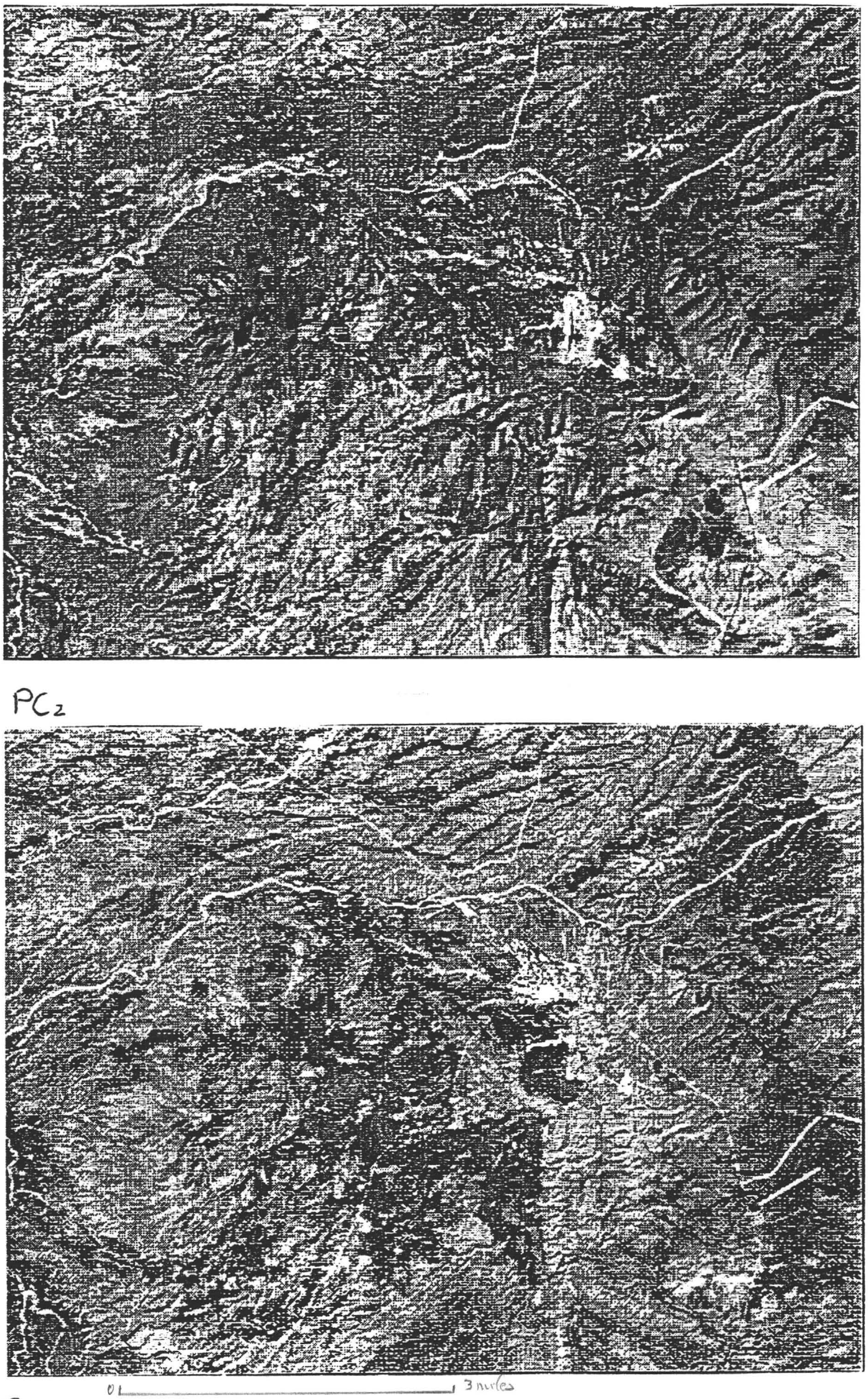
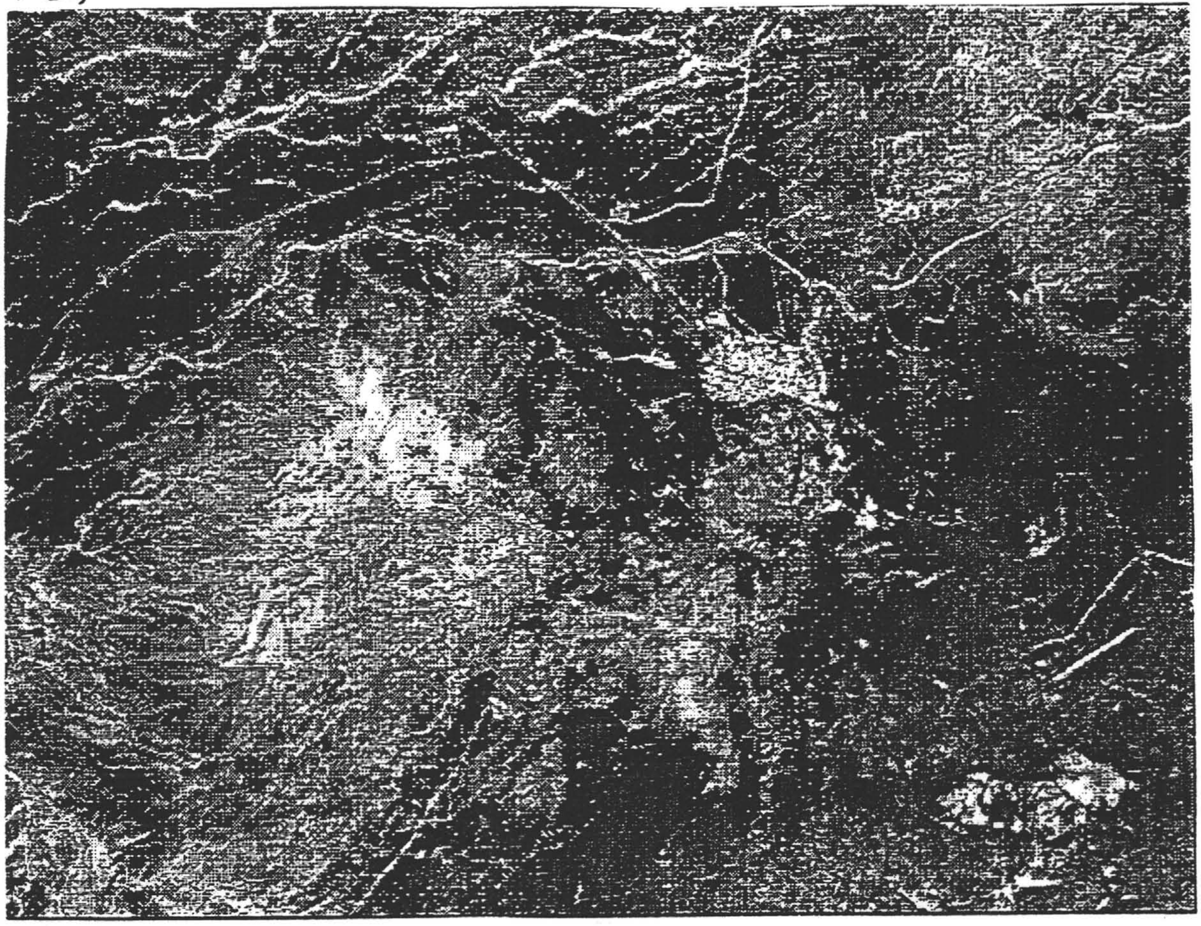
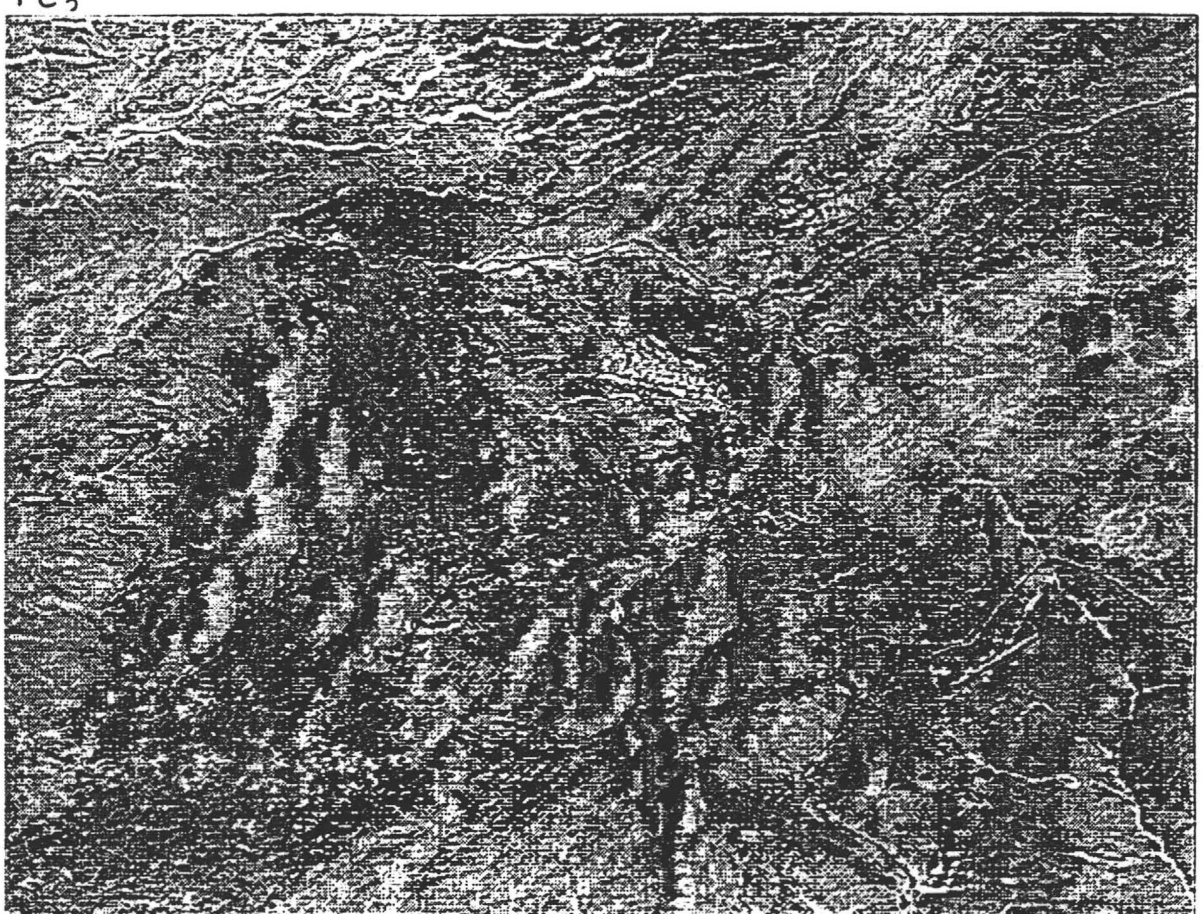


Fig. 8.

PC3

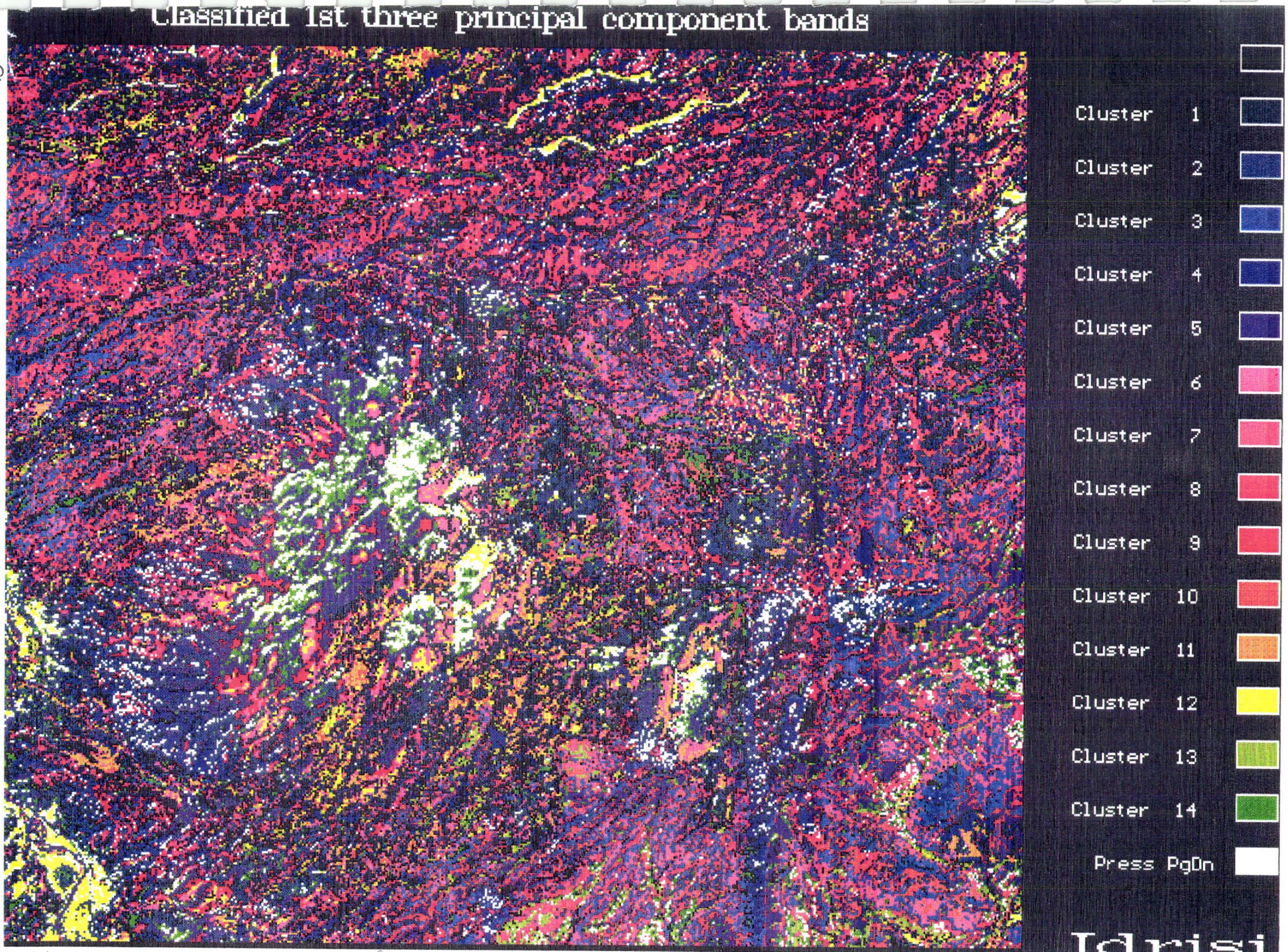


PC5



0 — 3 miles

fig. 8.



Classified 1st three principal component bands
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Cluster 7
Cluster 8
Cluster 9
Cluster 10
Cluster 11
Cluster 12
Cluster 13
Cluster 14
Press PgDn
Idrisi

Fig. 9.

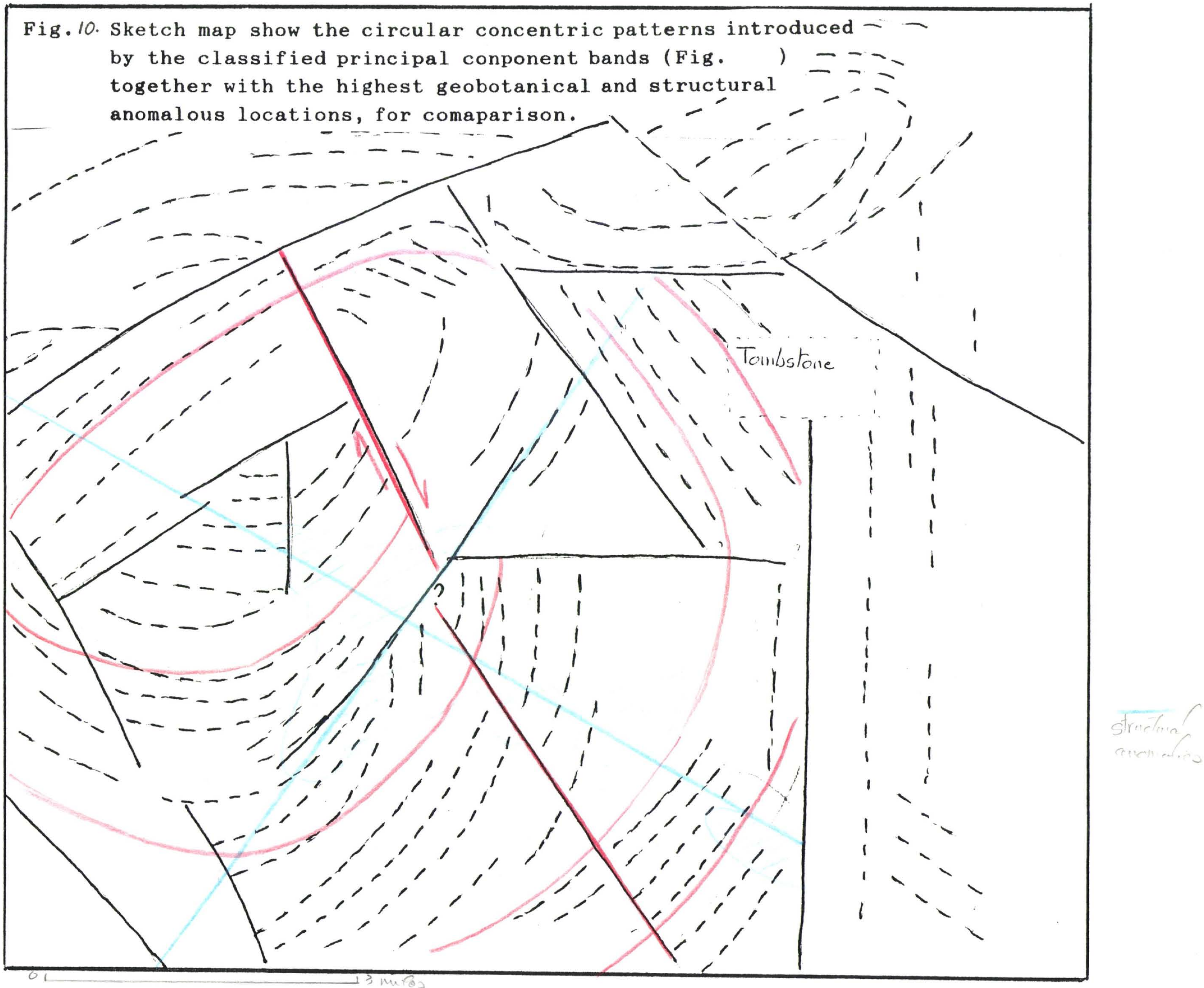


Fig. 10. Sketch map show the circular concentric patterns introduced by the classified principal conponent bands (Fig.) together with the highest geobotanical and structural anomalous locations, for comaparison.

CONCLUSION

Multile prophyry copper centers thought to occur associated with Laramide granodioritic to quartz monzonitic plutons within the Caldera complex (Briscoe,J.A.1982). The hydrothermal system is superimposed on the Paleozoic sedimentary sequence, hidden beneath the Uncle Sam quartz latite tuffs. The geobotanical and structural anomalies, in the present report, are strongly confirm the existance of that system.

The circular patterns observed in the composite principal component composite and classified image (fig. 10), recommend further structure analysis in the study area to produce reasonable interpretation.

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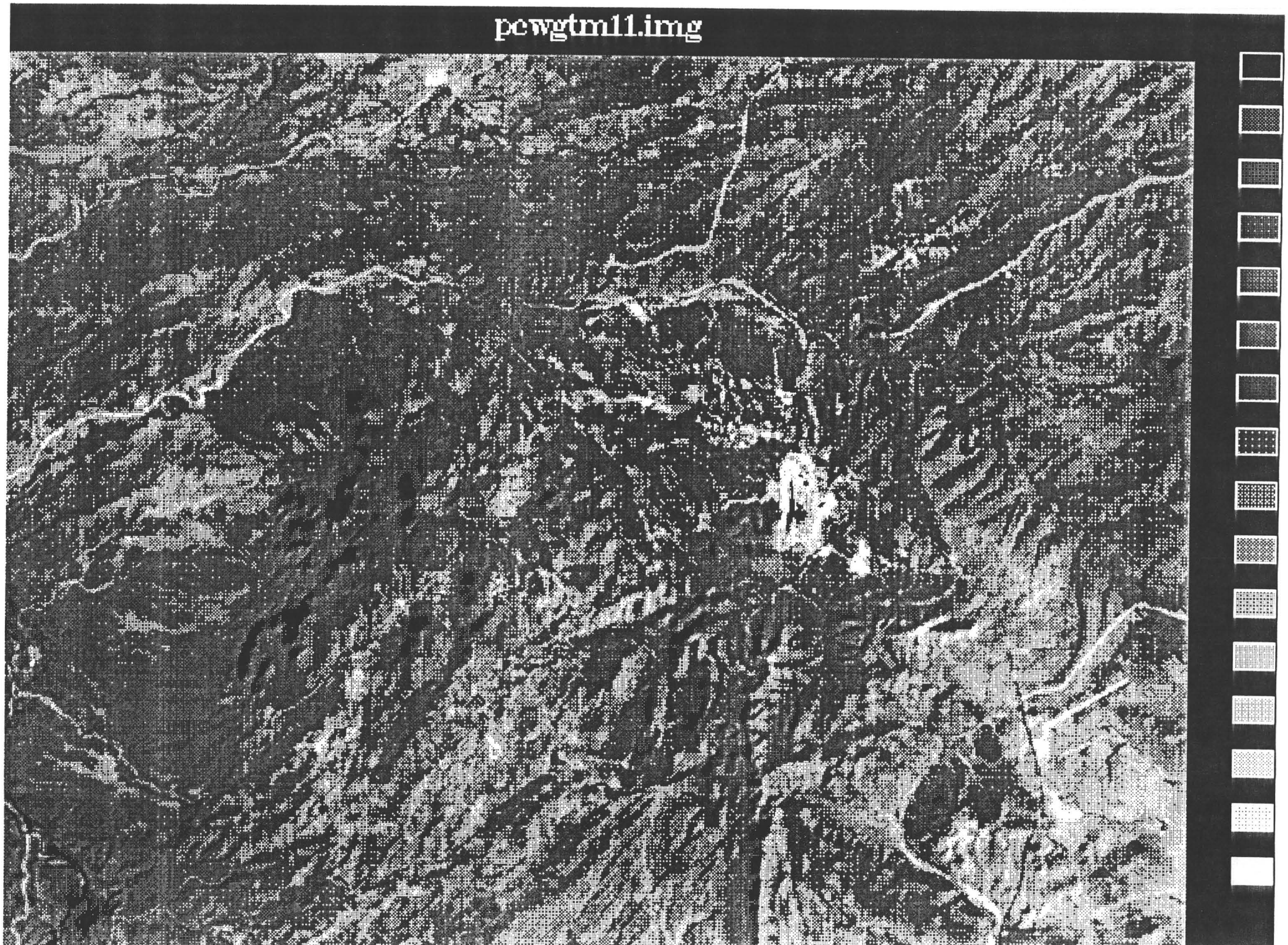
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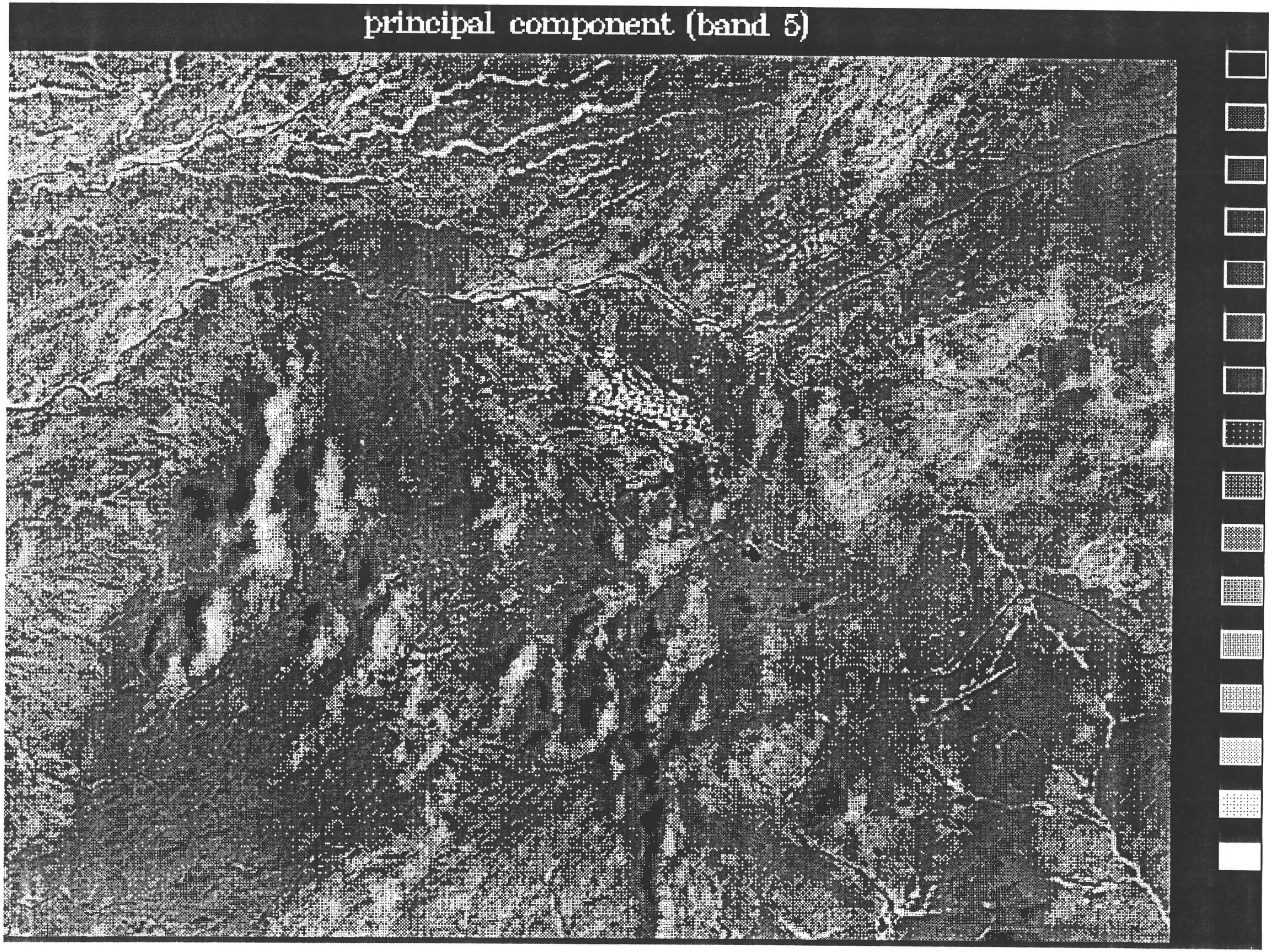
principal component (band 5)

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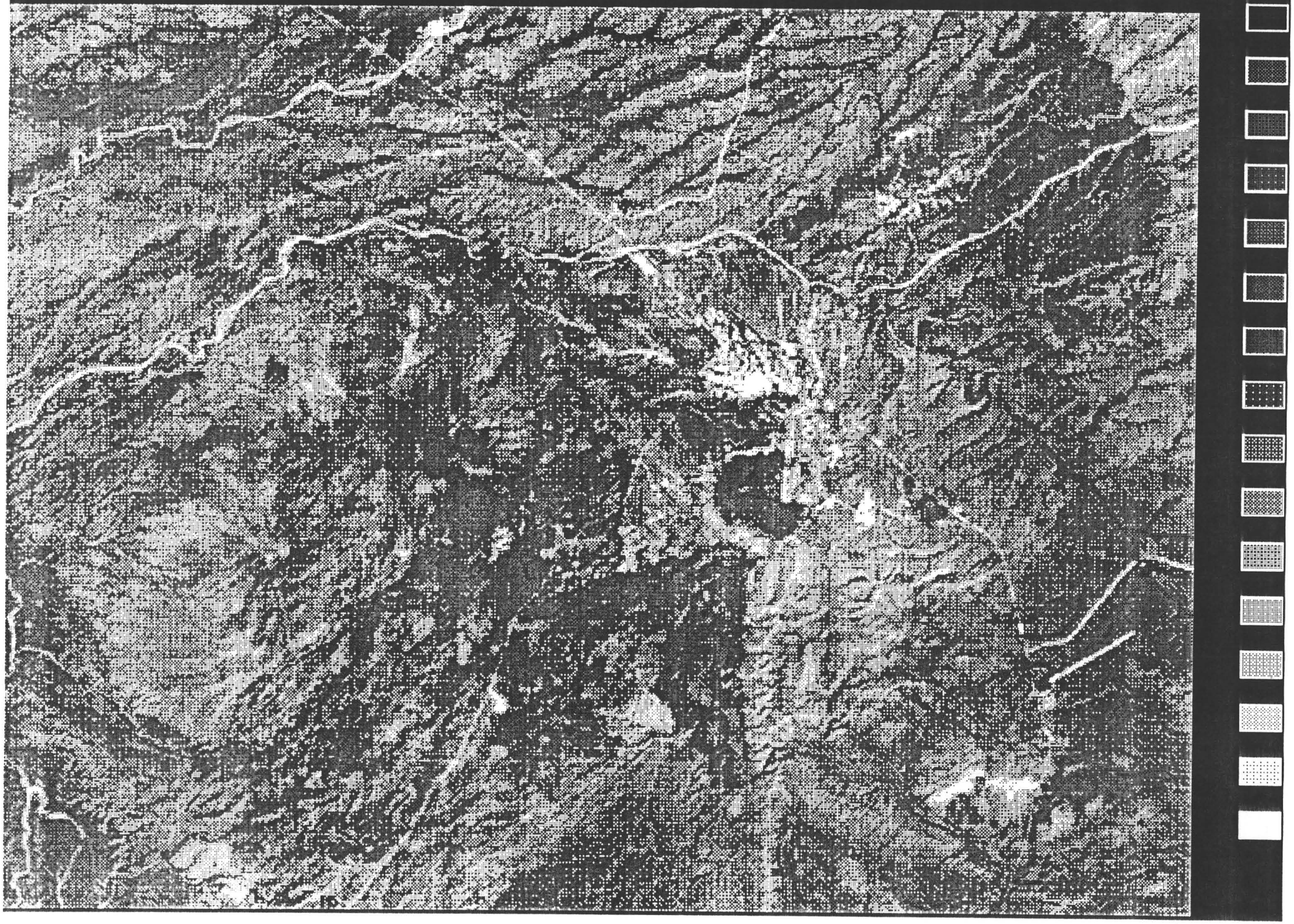

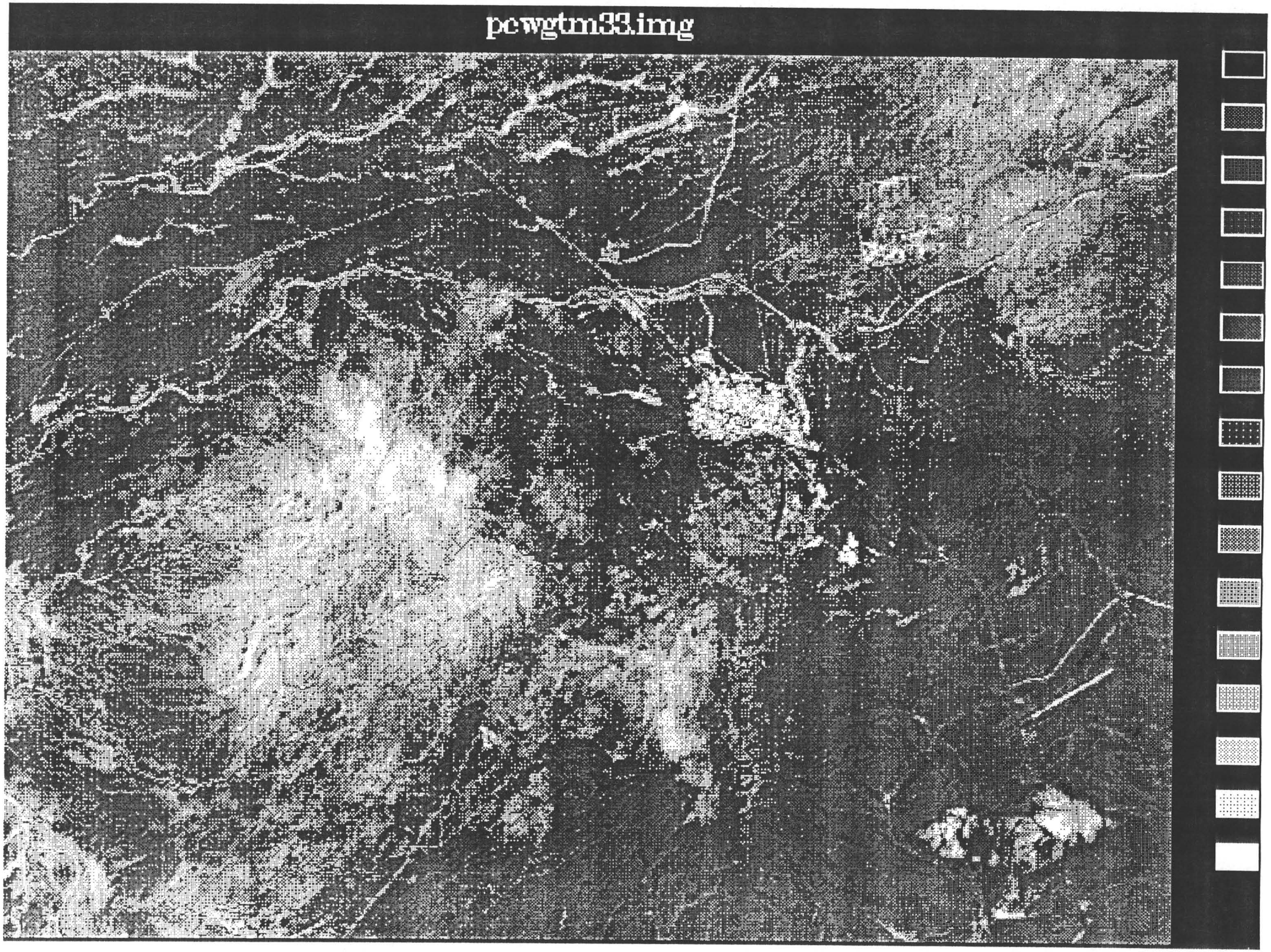
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first Three principal Component bands(Tombstone)