LOW SUN AIR PHOTOS

JAN 2 8 1989

Mr. Ralph Stein, Associate Director
Office of Systems Integration and Regulations
Office of Civilian Radioactive Waste Management
U. S. Department of Energy RW-24
Washington, D. C. 20545

Dear Mr. Stein:

Attached is a report written by NRC contractor personnel entitled "A Preliminary Review of Low Sun Angle Air Photos from the Yucca Mountain Area." This report is being provided for transmission to the Yucca Mountain Project Office (YMPO) because Max Blanchard (YMPO) has expressed interest in the low sun angle air photos which are the subject of this report.

If you have any questions concerning the attachment, please contact King Stablein (FTS 492-0446) of my staff.

Sincerely,

ORIGINAL SIGNED BY

John J. Linehan, Director
Repository Licensing and Quality
Assurance Project Directorate
Division of High-Level Waste Management

Attachment: As stated

cc: R. Loux, State of Nevada
M. Baughman, Lincoln County, NV
S. Bradhurst, Nye County, NV
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Lawrence Livermore National Laboratory

NUCLEAR SYSTEMS SAFETY PROGRAM
FTS 532-0268
L-196

December 10, 1988

Mr. Michael E. Blackford, MS-1WFN/4H-3
Project Officer, HLTR
Technical Review Branch
Division of High-Level Management
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: Transmittal of the Reference Technical Letter Report
NRC FIN A0297

Reference: "A Preliminary Review of Low Sun Angle Air Photos from the Yucca Mountain Area (Revised)," by H.L. McKague and D.W. Carpenter. 10pp.

Dear Mr. Blackford:

The purpose of this letter is to transmit the reference technical letter report prepared by H. L. McKague and D. W. Carpenter. This version of the reference letter report is a revised version of our report on the same topics submitted earlier on 31 October 1988.

During the project coordination meeting held in Livermore on Tuesday, 22 November 1988, we received NRC staff's comments on our earlier report prepared by Ms. C. Abrams, dated 16 November 1988. We in the present report attempted to address most of the NRC's comments. Both McKague and Carpenter used considerable amounts of their combined knowledge and experience, and technical judgment, in making the analysis and/or review of the photos.

If you have any questions, please let us know.

Sincerely yours,

Dae H. (Danny) Chung
Program Manager

DHC/ic
Attachment as stated.

cc: C. Abrams, NRC/HLTR

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A PRELIMINARY REVIEW OF LOW SUN ANGLE AIR PHOTOS FROM THE YUCCA MOUNTAIN AREA

by

H. Lawrence McKague
and
David H. Carpenter

INTRODUCTION

At the request of NRC (Task Letter 7/19/88) we have reviewed approximately 180 low sun angle photos over and around the proposed high level nuclear waste repository at Yucca Mountain, NV. The photos were taken for the State of Nevada. All photos reviewed were taken in the early morning, except flight line 5-9A, which was flown in the late afternoon. That flight line was essentially along the crest of Yucca Mountain and allowed the features on the west side of the crest and in Solatario Canyon to be illuminated. The photos reviewed for this report are listed in Table 1.

Methods and Limitations

This study was reconnaissance in nature, because time was not available to make a detailed study. Approximately 3-5 minutes were spent on each photo. Thus some subtle features may have been missed. The photos were examined stereoscopically with 3x magnification. With higher magnification additional subtle features might have been identified. Each photo was covered with mylar and the lineaments drawn on the mylar. Lineaments resulting from scarps or associated with tonal patterns in alluviated areas are identified on the mylar.

Numerous linear features were noted on the aerial photographs studied. Most were short, discontinuous stream channel segments or apparent bedrock joints. Lengths of these linear features chiefly ranged from about 100 to 1000 feet. Dominant directions were NNE to NE and NW to WNW.

However, at some locations longer linear features or alignments of linear features were noted within alluviated areas or along alluvium-rock boundaries. The low sun angle shadowing suggests or confirms the presence of scarps along parts of some of these features. These features may be faults or erosional features unrelated to faulting. Locations of such features by flight line and frame numbers and comments on observed characteristics are discussed in a later section.

10 pp.

Some lineaments were subsequently compared with faults on maps by Scott and Bonk, 1984 (Yucca Mountain), Cornwall (1972), Byers et al., 1976 (Timber Mountain), and Sargent et al., 1970 (Striped Hills). Those lineaments which were compared with mapped faults are noted in comments regarding specific flight lines.

Although not a specific task assignment, several young appearing volcanic features were noted during examination of the aerial photographs. Since areas of young volcanism could have tectonic significance, these were delineated on the photo overlays. Criteria used to define young volcanics were apparent intrusion into or flow onto alluvial deposits, relative lack of erosion, and the general absence of vegetation on these features which also stand out on aerial photographs as dark features with strong contrasts to their surroundings.

REQUESTED TASK

We were asked to comment specifically on four topics. They were:

1. an evaluation of the usefulness and quality of the photographs for examination of structural and geomorphic features;

2. assuming 1) results in a positive evaluation, the identification and description of faults, lineaments, and other important structural features;

3. an evaluation of the locations of surface facilities, portals and shafts in light of the structural features identified in 2); and,

4. a comparison of lineaments defined in Nancy Walker's report with those identified as a result of this study.

Topic 1. The quality of the photos is in our judgment quite good. Several photos have small flaws resulting from the processing. However, the photo overlap is quite good so that the analysis is little affected. Some mapped minor faults coincided with lineaments on the photos. This is indicative of the general good quality of the photos.

Topic 2. This topic is discussed in the following section.

Topic 3. Examination of the photos in and around the proposed locations of the surface facilities, portals, and shafts revealed no unexpected linear features; both the Ghost Dance fault and the Bow Ridge fault were identified.

Topic 4. Because of the large difference in scales of the remote sensing techniques, that is Landsat vs air photos at an approximate scale of 1:12,000, direct comparison of lineaments identified by Nancy Walker and lineaments identified in this study are difficult. All of Walker's lineaments in the vicinity of Yucca Mountain are at least 1.6 km (5250 ft) long and were often a composite of more than one feature (Walker et al., 1988, p. 16). Most of the lineaments picked up in this study were short linear segments of drainage or cliff faces.

In the vicinity of Yucca Mountain, Walker identified two predominant trends: (1) north-south and (2) northwest-southeast. Some of the lineaments are identical with known features such as Solatario Canyon and Yucca Wash. However, there were differences. While both these features stand out well on Landsat imagery, on the Yucca Mountain low sun angle (YMLSA) photos they showed up predominantly as discontinuous linear drainage segments, and occasional tonal differences. Walker's only northeast trending lineaments in the area covered by the YMLSA photos were the Rock Valley, Mine Mountain and Stage Coach fault systems. On the YMLSA photos the Rock Valley trend lineaments were detectable and were more pronounced than the Mine Mountain or Stage Coach trends.

In summary, the trends and some of the same features identified by Walker were identified in this study. However, a number of features that were too small to be seen by Walker were identified in this study, for example the Ghost Dance fault.

SPECIFIC FLIGHT LINES

A summary of major features seen on each flight line is given below.

1. Line 3-6 (Frames 1-20). A south to north morning flight line starting about eight miles west of Amargosa Valley, NV and just south of U.S. 95.

a) Frames 6 - 1, 2, 3 linear stream channel segments.

b) Frames 6 - 6, 7, 8, 9 aligned tonal patterns, linear stream channel segments, possible northwest facing scarps in alluvium visible locally especially on frames 6-7, 8, 9.

c) Frames 6 - 10, 11, 12, tonal, aligned drainage segments, possible northwest facing scarp. Linear north northeast trend in 3-4 million year old basalt may represent fault or feeder dike. This lineament should be field checked to determine its origin. There is no corresponding fault on Cornwall's map.

d) Frame 6-20, aligned tonals along alluvium-rock boundary, local linear stream channel segments.

2. Line 3-6a (Frames 1-16). A south to north early morning flight line. Starts in northeast corner of Crater Flat and proceeds north to Beatty Wash.

a) Frames 6a - 2, 3 aligned tonals along alluvium-rock boundary, same feature as visible in 3-6-20.

b) Frames 6a - 2, 3, 4, band of tonals in alluvium and along alluvium-rock boundary, possible northwest-facing scarp.

c) Frames 6a - 5, 6, 7, faceted ridge ends in older alluvium, tonals, possible northwest-facing scarps locally, linear stream channel segment at north end.

d) Frames 6a - 11 and 12, young-appearing volcanic feature, this may be a conical erosional feature.

3. Line 3-7 (Frames 1-25). A south to north morning flight line that starts about seven miles west of Amargosa Valley, NV just south of U.S. 95.

a) Frames 7 - 1, 2, 3, 4, groups of linear stream channel segments with northeast-southwest trends.

b) Frames 7 - 5, 6, 7, Lathrop Wells cinder cone, with radiating lineaments.

c) Frames 7 - 8, 9, 10, 11, aligned tonals in alluvium and at alluvium-rock boundary, faceted ridge spurs and possible west-facing scarps locally visible, especially frames 7-9 and 10.

d) Frames 7 - 8, 9, 10, 11, aligned tonals along alluvium-rock boundary, linear stream channel segments, located subparallel and southeast of Feature c.

e) Frames 7 - 12, 13, 14, west facing scarp, predates youngest alluvial fans, faint tonal in alluvium at south end.

f) Frames 7 - 13, 14, 15, 16, 17, 18, 19, aligned bands of relatively short tonals, northwest to west-facing scarps and linear stream channel segments, en-echelon with Feature e. Band curves from northeast trend at south end to north-northwest trend in northerly portion. On photo 3-7-15 trenches CF-2 and 3 are visible. The scarp at that location is visible.

g) Frames 7 - 20, 21, 22, 23, 24, 25, alignment of short west and northwest-facing scarps and tonals in alluvium or at alluvium-rock boundary.

h) Frames 7 - 22, 23, 24, deflected drainage.

4. Line 3-7a (Frames 1 - 21). A continuation of flight line 3-7; starts about 2.5 miles west of north end of Yucca Mountain. This flight line covers the area just west of Windy Wash.

a) Frames 7a - 1, 2, 3, 4, alignment of short west and northwest-facing scarps and tonals, same feature as visible in 3-7-20-25 with northward continuation.

b) Frame 7a - 1, deflected drainage, same as Feature h (frames 3-7-22-24).

c) Frames 7a - 1, 2, 3, west and east-facing scarps bound linear drainage segments.

d) Frames 7a - 4, 5, tonal, possible local west-facing scarp.

e) Frames 7a - 6 and 7, faceted spurs, linear drainage segments, feature trends northeast.

f) Frames 7a - 9, 10, young-appearing volcanic feature, or conical-erosional feature, northeast trending scarp or dike on south side.

g) Frames 7a - 12, 13, 14, east-northeast trending band of tonals and linear stream channel segments.

h) Frames 7a - 15, 16, 17, east northeast-trending tonal in alluvium, possible local scarp.

i) Frames 7a - 18, aligned tonals and possible short, southwest-facing scarps.

Flight Line 2-8a (Frames 1-7). This is a morning flight flown south to north starting at the south end of Jet Ridge. Because of lack of time only the photos between the southern end of the flight line and the Prow were examined.

a) Photo 2-8a-2. Linear drainage coincides with fault crossing Jet Ridge as mapped by Scott and Bonk (1984). This lineament is on trend with disrupted drainage noted on photo 5-9a-9.

b) Photo 2-8a-3. Linearity of Jet Ridge suggestive of fault.

c) Photo 2-8a-4. Small lineaments crossing west ridge coincide with faults mapped by Scott and Bonk (1984).

d) Photo 2-8a-7. Fatigue Wash narrows and becomes more linear. Possible lineament crossing the Prow coincides with fault on Byers et al. (1976) and Scott and Bonk (1984).

6. Flight Line 5-9a (Frames 1-13). This was a south to north late afternoon flight along the Crest of Yucca Mountain (CYM). Flight line starts over Stage Coach fault area.

a) Photo 5-9a-1. The Stage Coach fault shows up as linear drainage segment and as several tonal changes, all of which line up with NE trend.

b) Photo 5-9a-2. Stage Coach lineament is on this photo. The N-S trending southern extension of the CYM is present north of Stage Coach fault. Other than the ridge there are no visual lineaments associated with it.

c) Photo 5-9a-6. Several small east facing scarps occur west of the CYM. A trench was dug several hundred feet west of these questionable scarps. If the scarps are fault related and reflect the true movement this fault would be antithetic to the Solatario Canyon. These features are easily accessible and should be field checked.

The Abandoned Wash fault shows up as a N-S trending valley east of CYM. There appears to be a southern continuation of the

lineament that extends on to photo 5-9a-5. However, Scott and Bonk do not carry the fault beyond the southern end of Abandoned Wash. This area should be field checked to determine the nature of the southward continuation of the lineament.

d) Photo 5-9a-7. Several faceted spurs occur west of CYM. Again trenching was conducted in the area, but do not cross the trend of these features. A linear drainage segment occurs along the west side of Solatario Canyon Wash.

Several short NNW drainage segments occur at an angle to main drainage direction suggesting the possibility of fault control.

e) Photo 5-9a-8. Ghost Dance fault (also present on photo 5-9a-7) shows up as tonal difference crossing ridges. Several small tonal differences and linear drainage segments occur in Solatario Canyon.

f) Photo 5-9a-9. Shows Ghost Dance fault in vicinity of exploratory shaft. A tonal difference on Jet Ridge appears to extend into an area of disrupted drainage suggestive of right lateral displacement. This appears to correlate with a fault Scott and Bonk mapped on the east side of Jet Ridge, although they mapped it as a west dipping normal fault. This area should be field checked for lateral movement along fault and evidence for age of faulting. The term disruptive faulting is used to describe a slightly anomalous drainage pattern. The fact that the drainage is incised into moderately welded Tiva Canyon Member of the Paintbrush tuff (Scott and Bonk, 1984) suggests this is an old feature; nevertheless, it should be checked at sometime in the future.

g) Photo 5-9a-10. As Solatario Canyon narrows, drainage becomes more linear, defining Solatario Canyon. Fault extension to north is marked by tonal differences, wind gaps and small linear drainages. Many NW trending linear drainages occur on east side of Jet Ridge and north end of Yucca Mountain. In Teacup Wash a short linear suggest a scarp. This should be field checked. A fault can be seen off setting the tuffs on the north end of CYM. This fault was mapped by Scott and Bonk.

h) Photo 5-9a-13. This photo is north of CYM centered over Yucca Wash. The main drainage channel of the wash trends NNW. To the south the drainage is poorly developed and runs NNE off the north end of Yucca Mountain. Northeast of the main channel the drainage is much better developed with longer linear segments. These segments trended from NNW to N-S with NW trends predominating. This trend may reflect underlying structure. Scarps were observed.

7. Line 2-10a (Frames 1-12). Flight line flown south to north in morning. Starts just west of Busted Butte.

a) Frames 10a-1 & 2, tonals, possible west-facing scarps present locally in alluvium or along alluvium-rock boundary. May correlate with Solatario Canyon Fault.

b) Frames 10a - 4 & 5, west-facing scarp, tonals, linear drainage segments at south end.

c) Frames 10a - 5, 6, 7, tonals, fractures, degraded faceted ridge spurs. May correlate with Ghost Dance Fault.

d) Frames 10a - 9, 10, 11, 12, tonals, linear drainage segments, possible west-facing scarp visible especially on frames 11 and 12.

8. Flight Line 2-11 (Frames 1-24). This is an early morning flight line flown on 8-14-87, in a south to north direction. This line starts south of U.S. 95, about two miles west of Amargosa Valley, NV.

a) Photo 2-11-2. Photo is a short distance northwest of Amargosa Valley, NV. An old or little used drainage channel is accentuated by shadow or tonal change. Lineament has a NE trend.

b) Photo 2-11-3. Drainage channel described under 2-11-2 continues on to this photo. East wall of Forty Mile Wash is accentuated by shadows on left (west) side of wash. Forty Mile Wash changes direction from N-S, at south end of photo, to NNE in northern part of photo. An old drainage parallels both northern trend of Forty Mile Wash and the earlier described old "wash".

c) Photo 2-11-5. Forty Mile Wash and older drainage trend northeast.

d) Photo 2-11-6. Forty Mile Wash changes to a still more eastwardly trend in northern half of photo. An older poorly defined drainage also change direction at approximately the same position. Tonal change west of Forty Mile Canyon parallels the wash.

e) Photo 2-11-8. Trend of Forty Mile Canyon is well defined. Parallel tonal change occurs to west.

f) Photo 2-11-9. Drainage in center of photo extends northeast-southwest. Northeast extension trends into a possible bed rock fault as evidenced by a notch in a ridge in photo 2-11-10, and is subparallel to Forty Mile Wash.

g) Photo 2-11-10. Several faults cross small ridge and extend onto drainage channels. On west side of photo short drainage linears have a northwest trend.

h) Photo 2-11-12. Centered over Busted Butte, several bed rock faults visible. Faults in sand ramp along west side of Busted Butte are not visible.

i) Photo 2-11-16. South end of Fran Ridge. Four lineaments were mapped that coincide with faults mapped by Scott and Bonk (1984). The Bow Ridge fault and two nearby faults are well defined by drainage patterns. The Fran Ridge fault is less well defined.

j) Photo 2-11-17. Paintbrush Fault is poorly defined. Fran Ridge Fault was not defined by lineaments on photos.

k) Photo 2-11-20. South end of Midway Valley has short southeast trending drainage lineaments. Actual trace of Bow Ridge Fault as indicated by trench is not well defined. Abundant short to long linear drainage lineaments in Midway Valley

l) Photo 2-11-24. Centered just south of Yucca Wash, most drainage lineaments trended northwest-southeast. Several lineaments coincide with mapped faults north of Yucca Wash.

9. Flight Line 1-15 (Frames 1-25). Flight line is from south to north starting about 3 miles east of Amargosa Valley, NV along U.S. 95.

a) Photo 1-15-1. Center of photo is over southernmost part of Striped Hills. Rock Valley Fault system has been mapped as passing southeast of Striped Hills. A tonal difference and drainage lineaments may reflect trend of system. No scarps were seen. Bed rock faults are visible, crossing the Striped Hills.

b) Photo 1-15-5. Northeast trending drainage lineaments could reflect alternate interpretation of Rock Valley fault system.

c) Photo 1-15-8. North and northeast trending faults in Little Skull Mountain coincide with drainage lineaments.

d) Photo 1-15-15 should be on projection of Mine Mountain fault. All lineaments are north northeast drainage segments, none parallel to northeast trend of Mine Mountain fault. No northeast trends were on photos 1-15-14 and 1-15-16.

e) Photo 1-15-17. North and north northeast trending drainage lineaments may be coincident with faults in Calico Hills.

f) Photo 1-15-20. East northeast trending tonal and drainage lineament, does not appear to coincide with known fault.

g) Photo 1-15-23. Short northwest and northeast drainage lineaments. Northwest trend, especially on 1-15-24 may parallel mapped faults.

10. Flight Line 1-16 (Frames 1-24). A south to north early morning flight line 3 to 4 miles east of Amargosa Valley, NV. Easternmost flight line starts at U.S. 95 and proceeds north.

a) Photo 1-16-1. Tonal and drainage segments may reflect Rock Valley fault system. Sargent, McKay and Birchfiel (1970) show the fault, further west, closer to Striped Hills.

b) Photo 1-16-2. Two drainage lineaments occur on east side of photo. These lineaments project towards Sargent et al. inferred position of the fault.

c) Photo 1-16-6. Northeast trending drainage lineaments could represent an alternate position or splay of Rock Valley fault system that would pass north of the Striped Hills.

d) Photo 1-16-9. North northeast trending lineaments parallel to mapped faults in Little Skull Mountain. Note: in generally good agreement in overlap with photos in Flight Line 1-15.

e) Photo 1-16-14. Northeast trending lineament between two hills in southwest quadrant of photo and drainage lineament in northeast quadrant may be an extension of, or parallel to Mine Mountain Fault. This is a little south of projection of fault. Origin of these lineament should be checked as it may indicate a realignment of the Mine Mountain fault, a new fault, or be an artifact of erosion.

f) Photo 1-16-17. Predominantly north south drainage lineaments on west side of photograph.

g) Photo 1-16-20. Northeast and northwest drainage lineaments in Calico Hills.

REFERENCES

Byers, F. M. et al., 1976, U.S. Geol Surv., Miscell. Invest. Ser., Map I-891.

Cornwall, H. R., 1972, Nevada Bureau of Mines and Geology, Bulletin 77.

Sargent, K. A. et al., 1976, U. S. Geol Surv., Map GQ 882.

Scott, R. B. and Bonk, J., 1984, U.S. Geol Surv., OFR 84-494.

Walker, N. D., McKague, H. L., and Siemmons, D. B. 1988, LLNL, UCRL 98742.

TABLE I

LIST OF AIR PHOTOS REVIEWED

Flight Line	Photo Number
3-6	1 to 18
3-6a	1 to 16
3-7	1 to 25
3-7a	1 to 21
2-8a	1 to 7
5-9a	1 to 13
2-10a	1 to 6
2-11	1 to 24
1-15	1 to 25
1-15	1 to 24