

To: H. D. Pilkington
From: R. M. Sadowski
Subject: Fish Lake-Alum LANDSAT Study

cc: J. Roth

Introduction

A 25 mile x 25 mile area centered on the north end of the Silver Peak Range, Nevada was extracted from a LANDSAT CCT for data enhancement. This data set was used to evaluate the distribution and spacial associations of hydrothermally bleached and ferric iron stained rocks lying within the Fish Lake and Alum geothermal prospects.

Enhancement procedures included mapping high albedo zones, edge enhancement, principal component analyses and band ratioing. Output products consist of 35 mm slides, 8 x 10 prints of ^{selected} slides and four interpretation maps.

False color composite (FCC) 457

Slide #1 has been prepared by color coding LANDSAT bands 4, 5, and 7 in blue, green and red. The general outcrop patterns of light colored to dark colored rocks can be discerned in this image. The Fish Lake prospect shows two groups of bright colored rock units, ash flow tuffs, separated by a dark brown, welded tuff, unit. The Alum area shows one prominent bright area.

FCC 457 w/High Albedo

Slide #2 was prepared by selecting the brightest pixels from band 5 and overlaying them on the FCC of bands 4, 5 and 7. This technique, density slicing, allows the interpreter to highlight areas of possible bleaching for later comparisons.

with lithology and ferric iron zones .

Principal Component Analysis (PCA)

The sequence of slides 3 through 6 show components 1 through 4 as grey level images. Component 1 is an average grey level image of all 4 LANDSAT bands and in general describes intensity variations, albedo, better than any single band. Component 2 shows vegetated areas having the brightest grey levels, the ash flow tuffs as middle grey and shales, basalts and alluvium as dark grey. Component 3 shows the shales and basalts as middle grey and the ash flow tuffs as dark grey. ~~Combining~~ ^T these 3 components ^{were combined} to produce a color composite image, ~~yielded~~ slide #7, ~~This image~~ which shows component 2 in blue, component 1 in green and component 3 in red. ^(This image provided) ~~produced~~ a much better lithologic ^{discrimination} ~~discription~~ map than the FCC 457. The ash flow tuffs are shown in light green and blue except for the west half of the Fish Lake prospect where they appear reddish-brown. Dark rocks such as shales and basalts appear in bright red. Vegetation appears as magenta colored areas and playas in yellow. Slide #13 shows a 12.5 x 12.5 mile subscene of the Fish Lake prospect and slide #17 shows a similar sized area for Alum. Two lithologic interpretation maps at a scale of 1:24,000 were prepared from ~~these~~ slides. Two 8 x 10 prints of each area, ~~slide #13 and #17,~~ were also made.

Band Ratio Composite (BRC)

A band ratio color composite image, slide #8 was prepared and displayed as 4/5 (blue), 5/6 (green), and 6/7 (red). Ferric iron enriched zones appear as orange-red colors in this image. The Fish Lake Prospect shows no large clustering of ferric iron while the ^Aalum area clearly shows a ferric iron signature. Dark shaley rocks in the EW range ^{north of} with the Fish Lake ^{Valley} appear ⁱⁿ as a bluish white color. Shale units east of the playa in Fish Lake Valley, however, appear to be iron stained. The welded tuffs lying within the Fish Lake prospect are shown in black. The bright blue colors lying in the south and southeast part of the image are partially due to the vegetation cover. Slide #14 shows a 12.5 x 12.5 mile subscene of the Fish Lake area and slide #18 the same sized area for the Alum prospect. The difference in color between these two slides is a result of *different stretching applied to the* ~~how the histograms of the three ratios have been stretched~~ *between 0 black and 225 white.*

High Albedo - Ratio - PCA

Slide #9 shows how the basic data can be recombined by the interpreter to produce a combined lithologic-alteration map. This image uses a B&W copy of PC-1 as a base with high albedo zones shown in blue, low 4/5 ratio values shown in green and low PC-3 grey levels displayed in red. This combination of data is used to show the relationship between possible hydrothermally bleached areas lying within outcrops (blue), ferric iron in dark rocks (green) and ferric iron in light colored rocks (yellow). The dark rocks are generally

shaley units while the light rocks are tuffs. The Fish Lake area, slide #15, ~~appears to have~~ ^{shows} isolated green pixels of possible ferric iron origin ~~that lie~~ ^{the} within a welded tuff unit. The Alum area, slide #19, shows only a few yellow ~~and~~ ^{or and} green pixels but may be a result of too sharp a cut ~~off~~ ^{off} on the histogram of the 4/5 ratio. The three ratio color composite, slide #8, indicates that more iron is present at the Alum prospect. An interpretation map at a scale of 1:24,000 and 8 x 10 prints were made for both of these areas.

Edge Enhancement

Two edge enhancement images, slides #10 and #11, were prepared from LANDSAT band 5 by using directional first derivatives. Slide #10 shows NS/EW enhanced edges and slide #11 NW/NE enhanced edges. This procedure results in a middle grey shaded image with white and black accentuated edges. Major topographic, tonal and stream drainage trends are highlighted. These images can be used to map the location of linear features without the distraction of color changes.

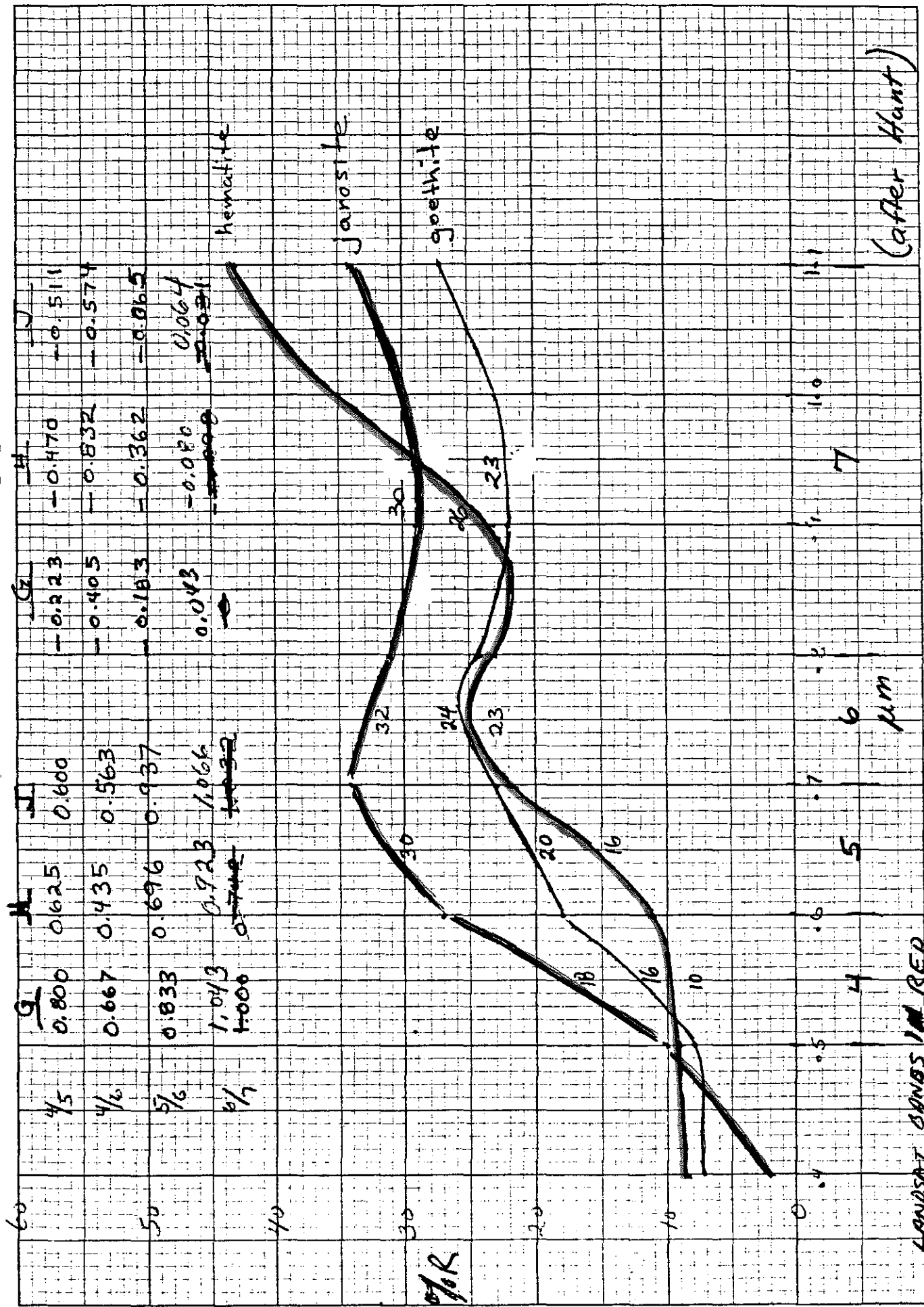
Combination of High Albedo, PCA and Edge Enhancement

Slide #12 was prepared by displaying PC1 in blue, high Albedo areas in black, low PC-3 values (light rocks) in turquoise, NW/NE edges in green and NS/EW edges in red. Edges that appear yellow are ones that were pick ~~up~~ ^{by both} by the edge enhancement filters. This type of approach would be used to locate areas having similar lithologic and structural characteristics. Slides #12 and #20 show 12.5 x 12.5 mile subscenes of the Fish Lake and Alum areas.

FISH LAKE-ALUM GEOTHERMAL AREASLANDSAT SLIDES

1.	FCC 457	25 x 25 miles
2.	FCC w/ high Albedo	25 x 25 miles
3.	PC-1	25 x 25 miles
4.	PC-2	25 x 25 miles
5.	PC-3	25 x 25 miles
6.	PC-4	25 x 25 miles
7.	PCA 213	25 x 25 miles
8.	BRC 4/5, 5/6, 6/7	25 x 25 miles
9.	High Albedo, low 4/5, ^{low} low PC-3	25 x 25 miles
10.	E. E. NS/EW	25 x 25 miles
11.	E. E. NW/NE	25 x 25 miles
12.	High Albedo, PC-3, E.E.	25 x 25 miles
13.	Fish Lake PCA 213	12.5 x 12.5 mile
14.	Fish Lake BRC 4/5, 5/6, 6/7	12.5 x 12.5 mile
15.	Fish Lake H.A., low 4/5, ^{low} low PC-3	12.5 x 12.5 mile
16.	Fish Lake H.A. low PC-3, E.E.	12.5 x 12.5 mile
17.	Alum PCA 213	12.5 x 12.5 mile
18.	Alum BRC 4/5, 5/6, 6/7	12.5 x 12.5 mile
19.	Alum H.A., low 4/5, low PC-3	12.5 x 12.5 mile
20.	Alum H.A., low PC-3, E.E.	12.5 x 12.5 mile

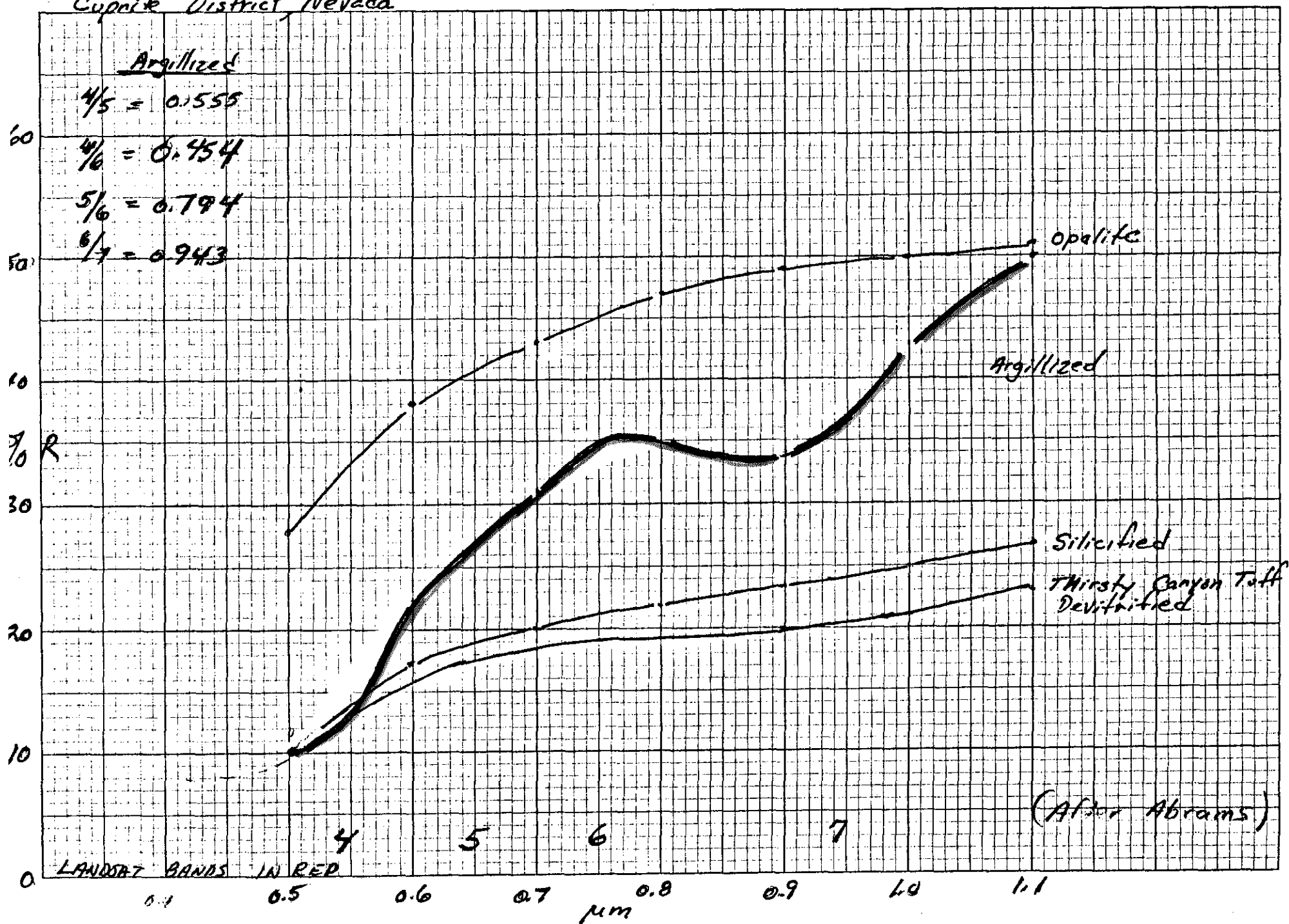
In



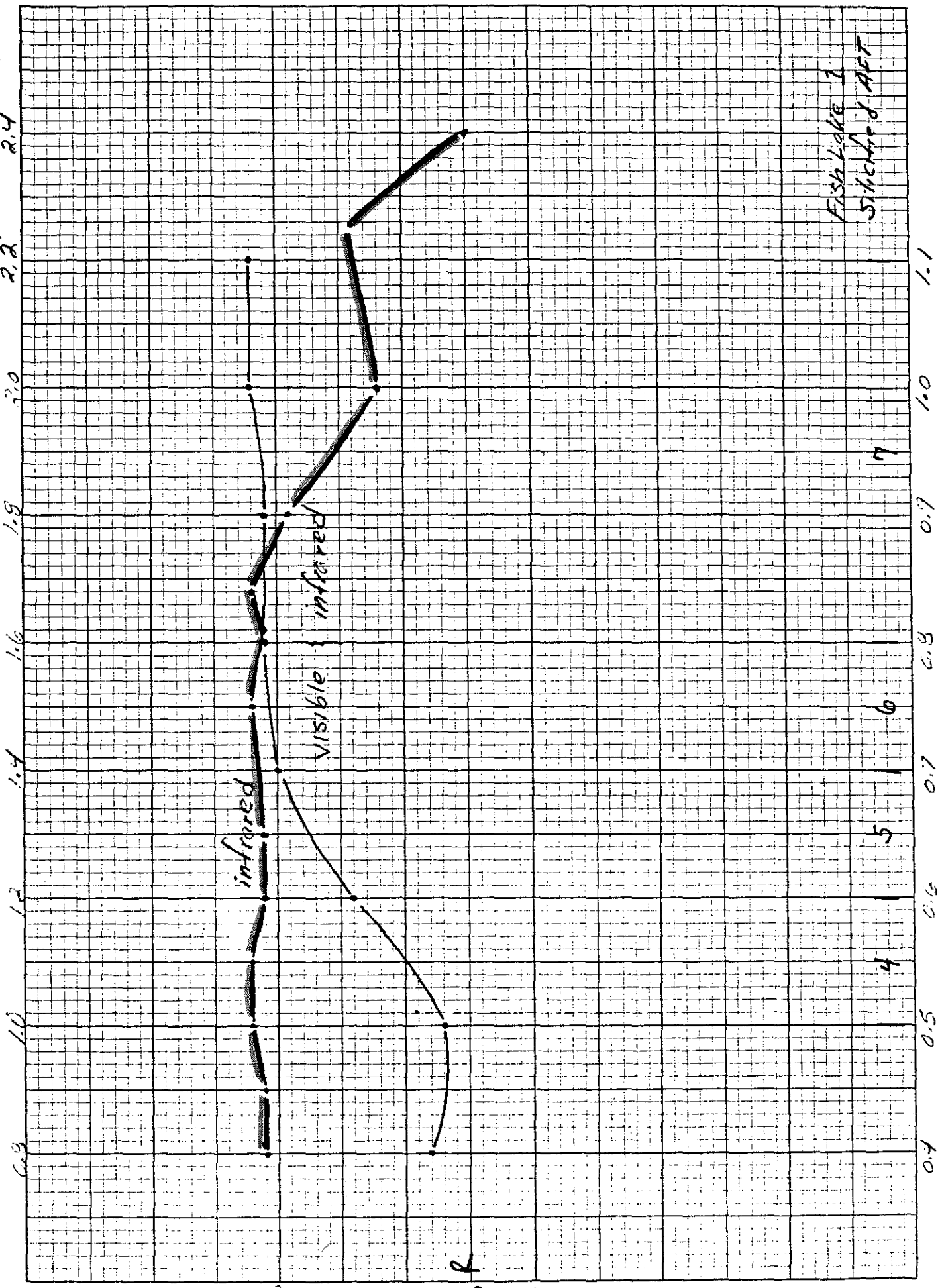
(after Hunt)

LANDSAT BANDS 1-4 RED

Cuprite District, Nevada

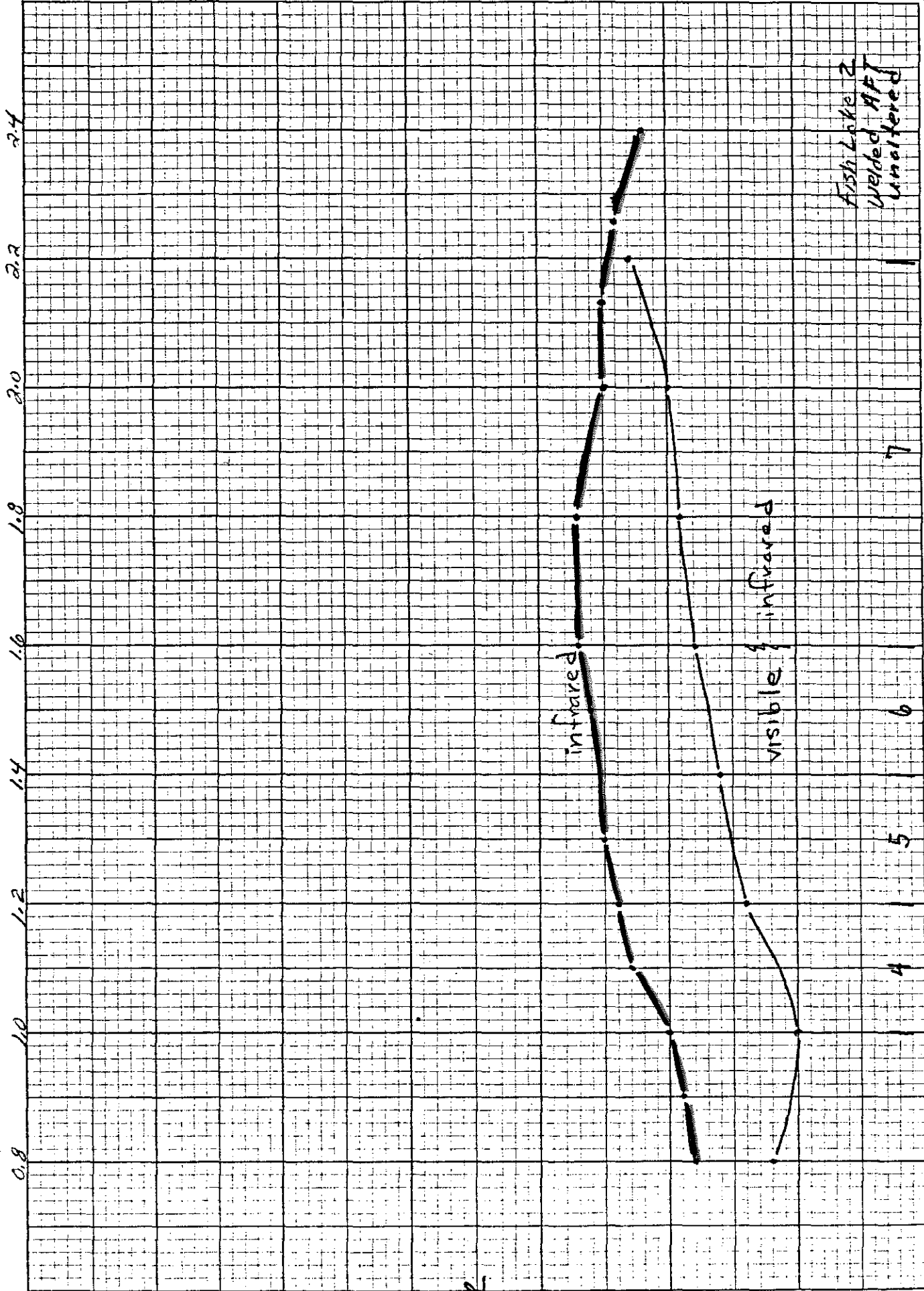


μm



Fish Lake I
Simplified AFT

μm



Fish Lake 2
Welded HT
Unaltered

1.1

1.0

0.9

0.8

0.7 μm

0.6

0.5

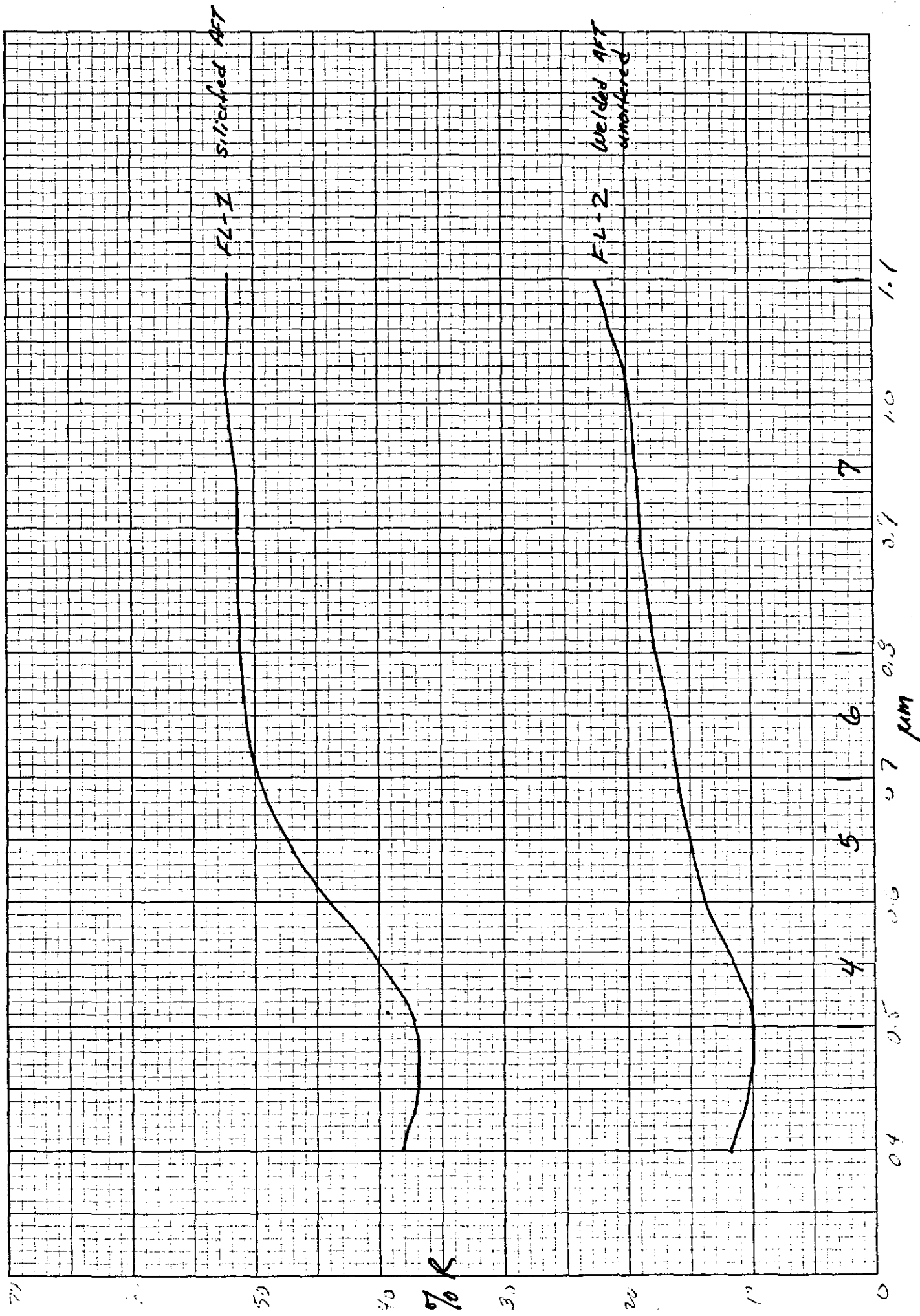
0.4

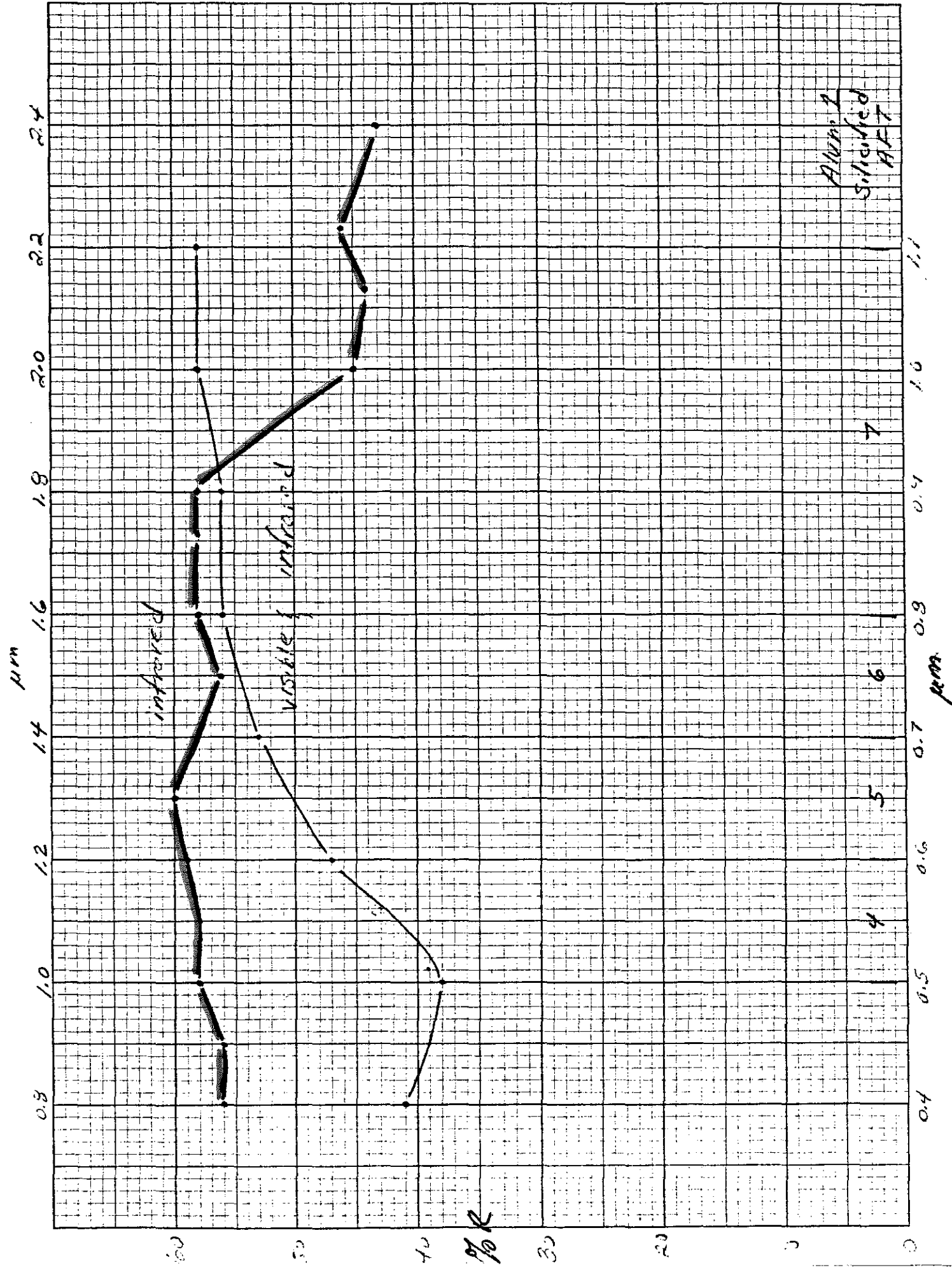
0.3

0.2

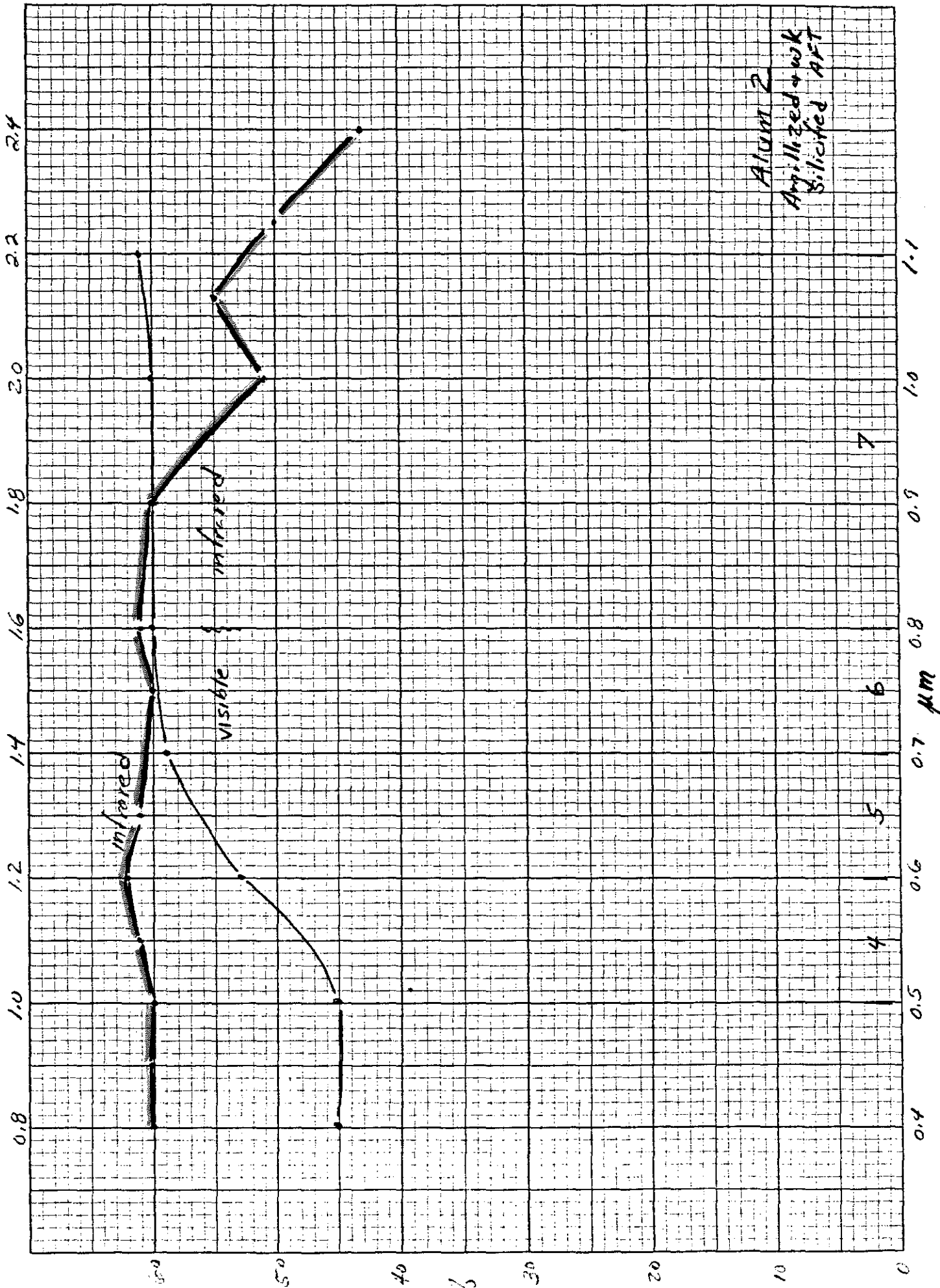
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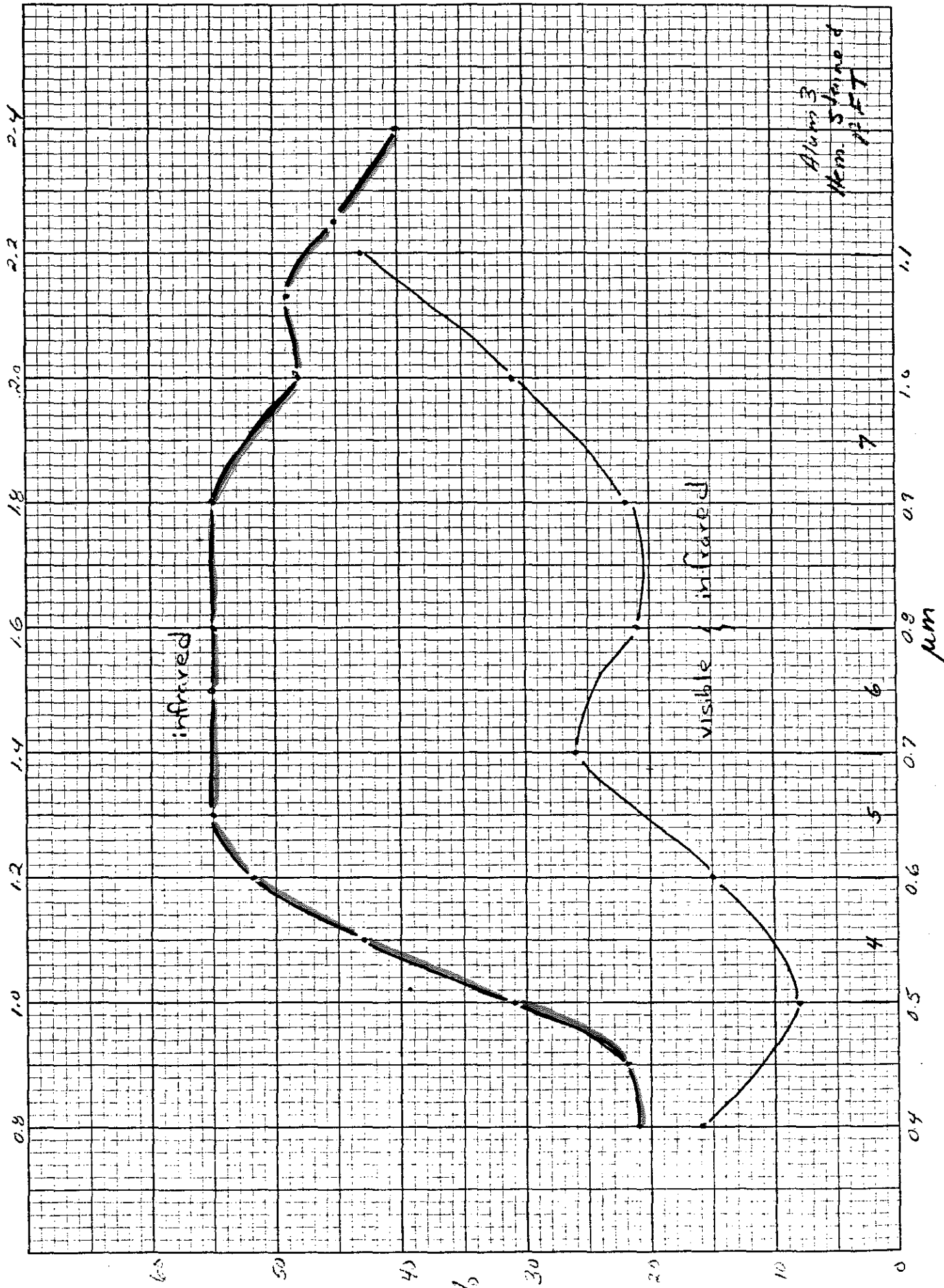
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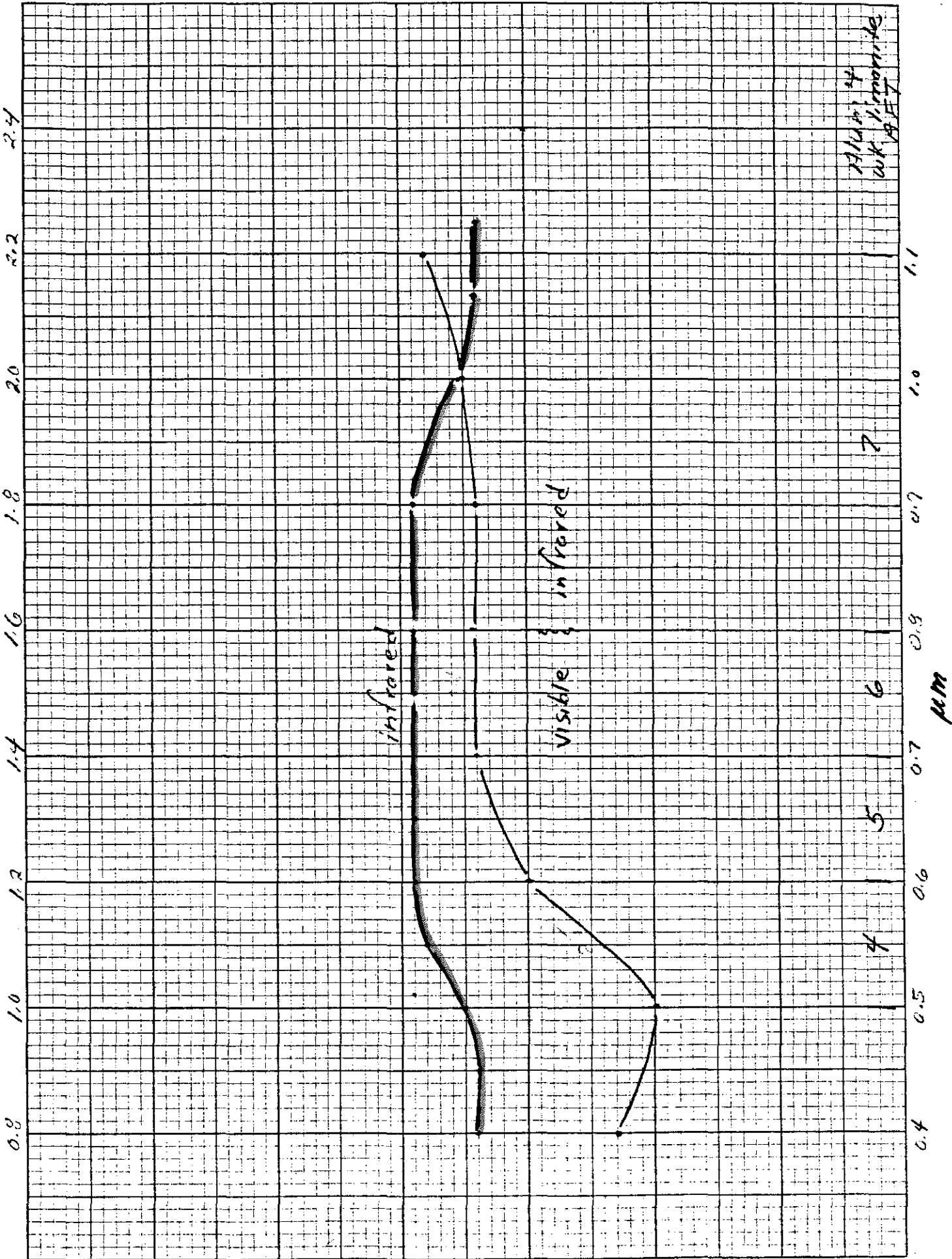


μm





μm



μm

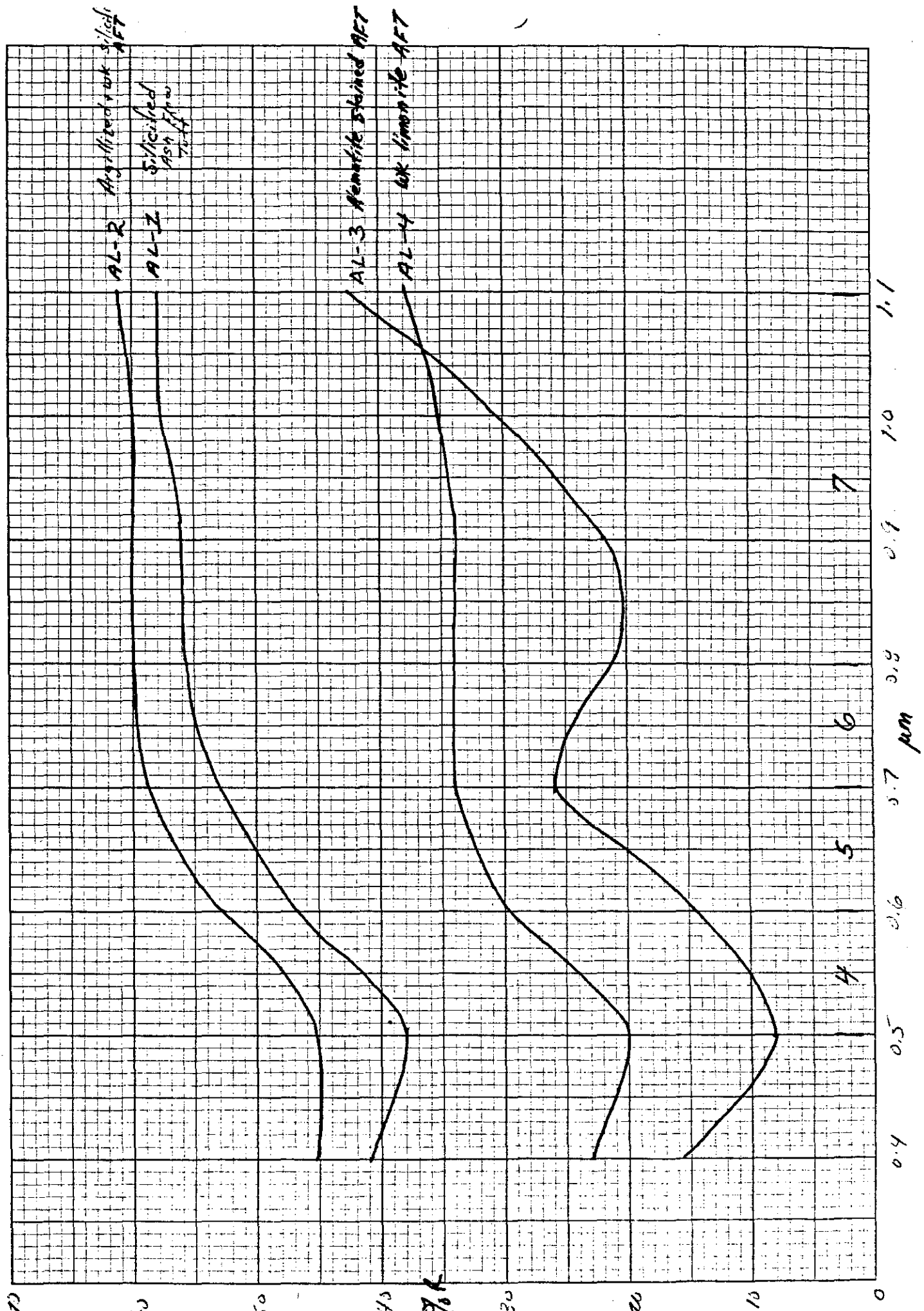
Aluminum Oxide
with AlF₃

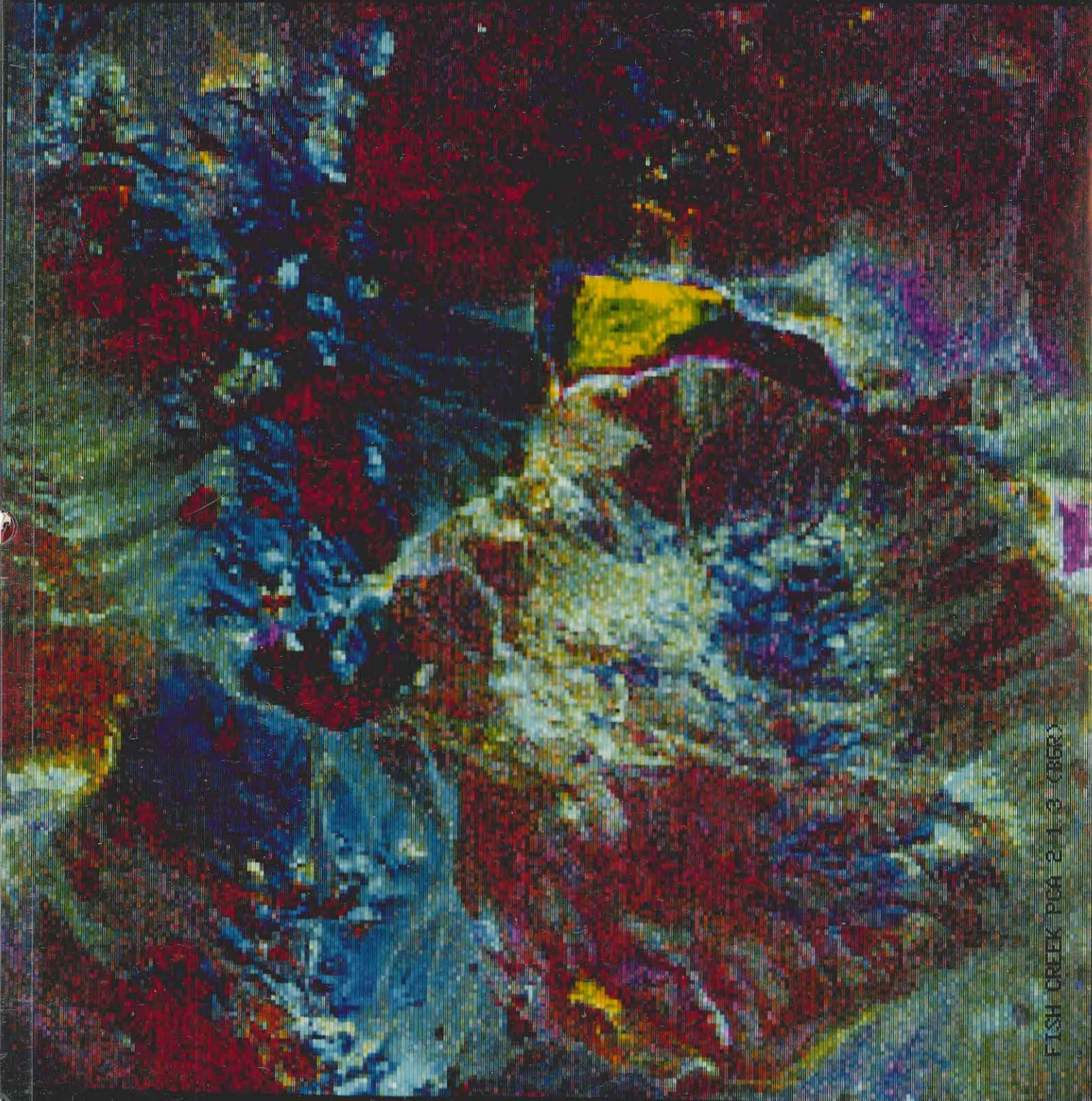
7

5

4

6

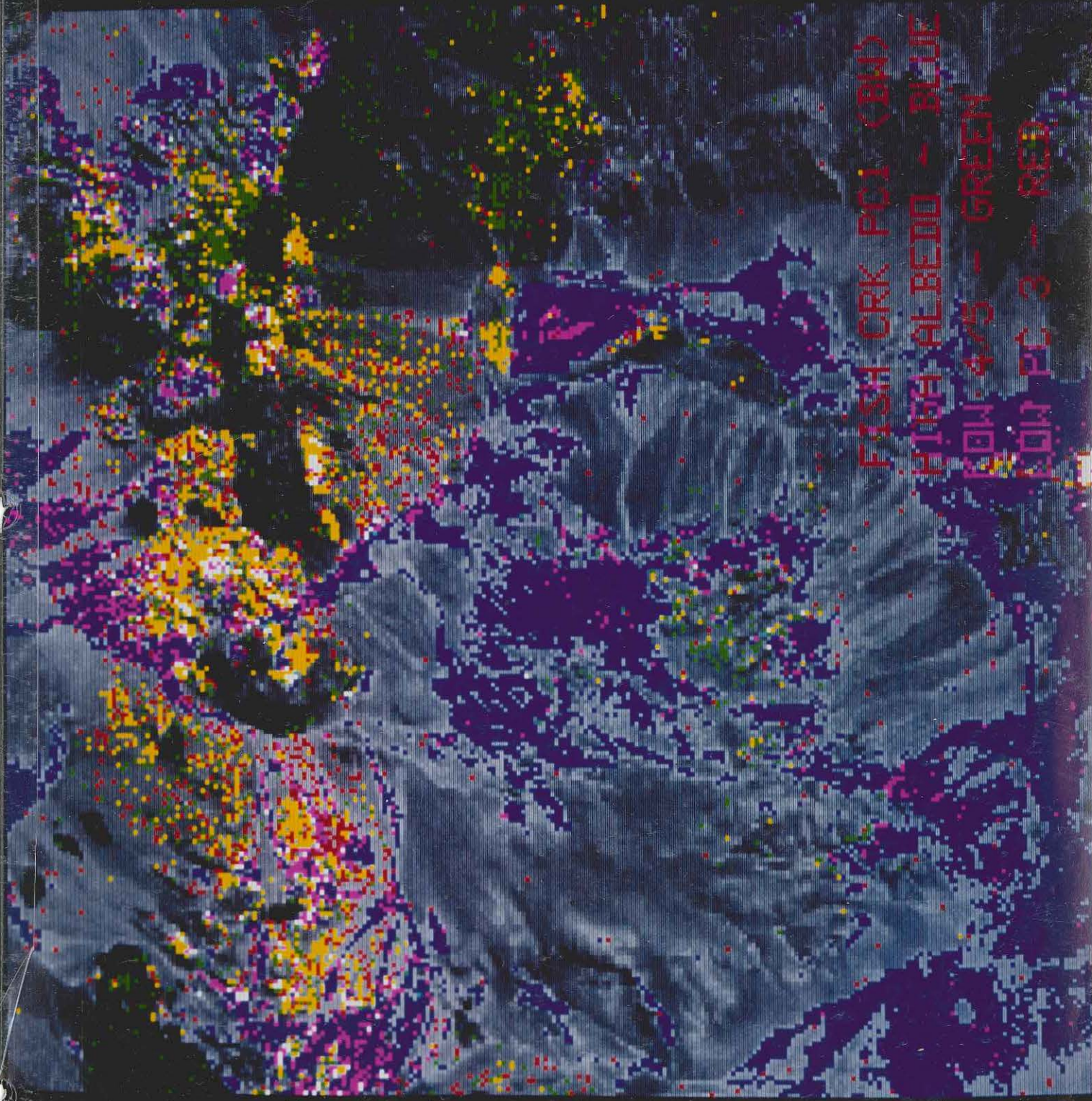




FISH CREEK PCA 2-1-3 (CHER)



ALUM PCA 2 1 3 (BGR)



FISH CREEK POI (BND)
HIGH ALBEDO - BLUE
LOW 475 - GREEN
LOW 3 - RED

ALUM AREA FC1 (BAD)

HIGH ALBEDO - BLUE

LOW 4.5 - GREEN

LOW FC 3 - RED

