Assignment Title:
Part 1: Thermal Infrared Imagery
Part 2: Differentiating geologic units

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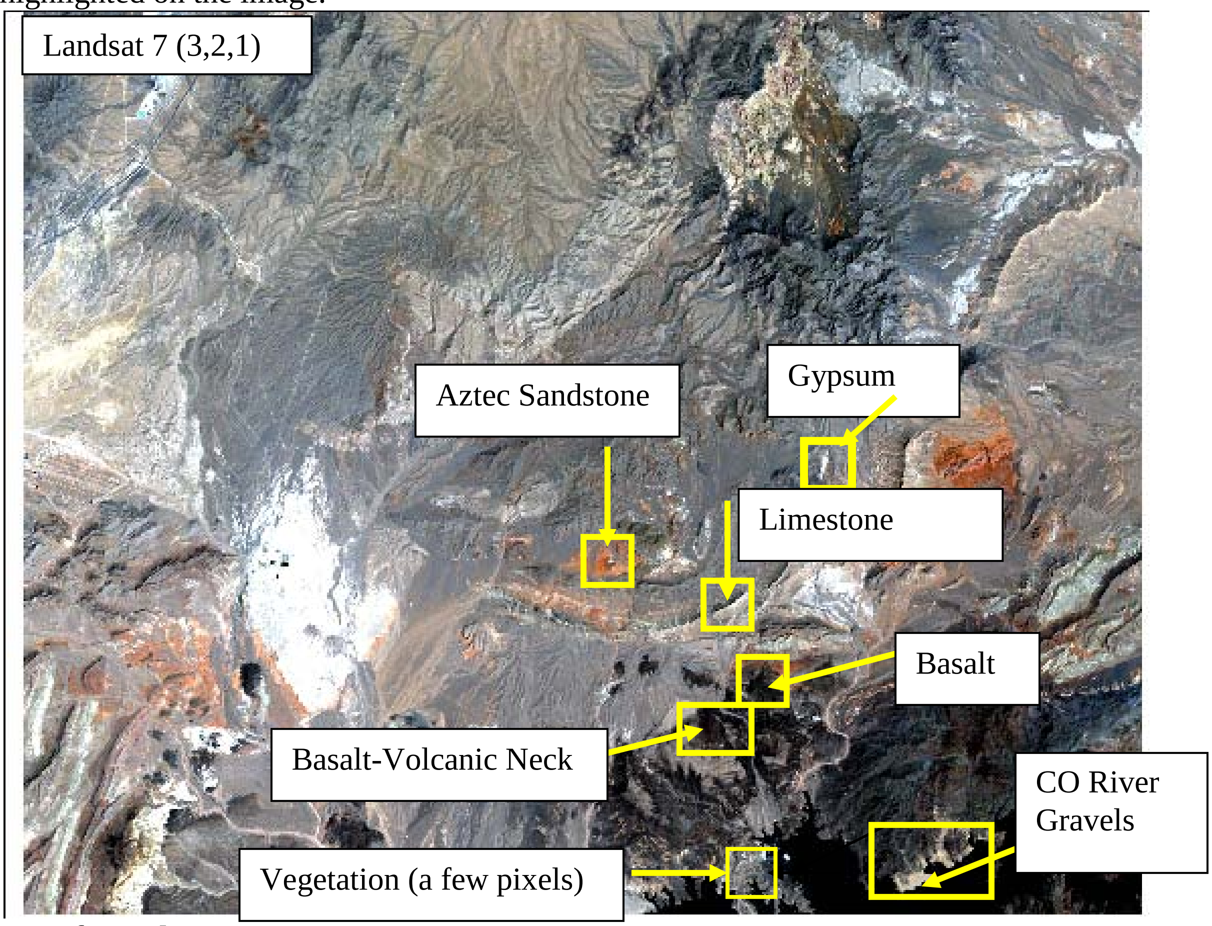
Lab 5

Part 1: Thermal Infrared Imagery

Part 2: Differentiating geologic units

The goal of this lab is to have you determine what wavelengths are best for discriminating between pairs of surface materials. Two materials may look similar in some wavelengths, but are easily discriminated (i.e. mappable) in others-remember the amethyst example from class. In Part1, you will practice with TIR imagery and then you will apply your new knowledge about TIR imagery and previous knowledge about VIS/NIR/SWIR to differentiate geologic units in Part 2.

Below is the Landsat image from Labs 2/3 with the geologic units you will be investigating highlighted on the image.



Prep for Lab:

- ✓ *Open LasVegas_b123457_refl_mod_rockss.img* [1]
- ✓ *Collect a spectrum from each of the materials identified in the image above, label each in the legend and use an appropriate Y axis.*
- ✓ *Keep this window open*

<u>*D1. Turn in a print screen of your spectra.*</u>

- ✓ *Open Lakemead_tir_radiance.img*[2]

Part 1: Thermal Imagery

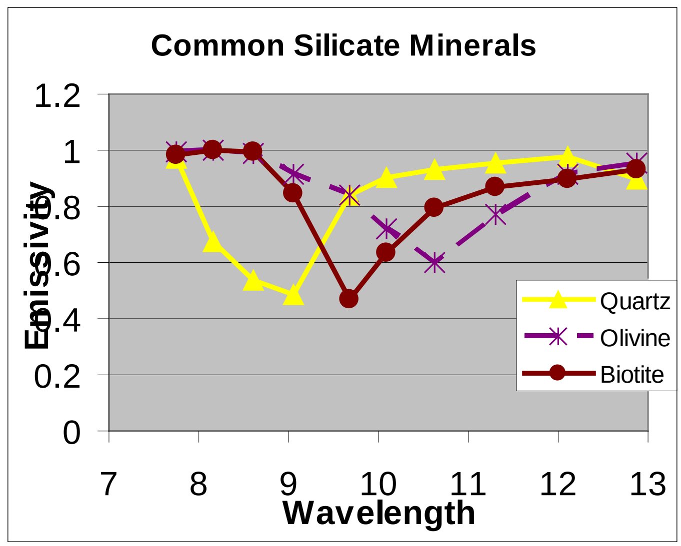
The TIR image is from the MASTER instrument with 10 bands in the TIR region 7um to 13um. This is an airborne instrument resulting in the "strips" of data.

	Left (um)	Right (um)
1	7.578	7.937
2	7.938	8.382
3	8.429	8.796
4	8.821	9.277
5	9.484	9.886
6	9.903	10.290
7	10.317	10.921
8	10.964	11.652
9	11.850	12.347
10	12.632	13.111

1. *The pixels in this image are in radiance. What two physical properties of a surface material control the amount of radiance emitted?*

2. *Would the Aztec Sandstone have the same spectra on an image taken on a different day? Why?*

To the right are <u>emissivity</u> spectra of common minerals that have very strong absorption features. Each point represents an individual MASTER band. The Si-O bond in silicate minerals vibrates in the 7-14um region causing the strong absorption features.



3. *Which mineral (quartz, biotite or olivine) has the strongest Si-O bond? Why?*

4. *If you created a MASTER (743) image, what color would quartz rich materials appear? (Use the table of band wavelengths above)*

- ✓ *Create a 743 image of the TIR radiance image*

5. *Which two materials listed at the beginning of the lab appear to be quartz rich?*

- ✓ *Create a true color image in your LasVegas_b123457_refl_mod_rockss.img*
- ✓ *Look at the two materials from question 5 in the VIS*

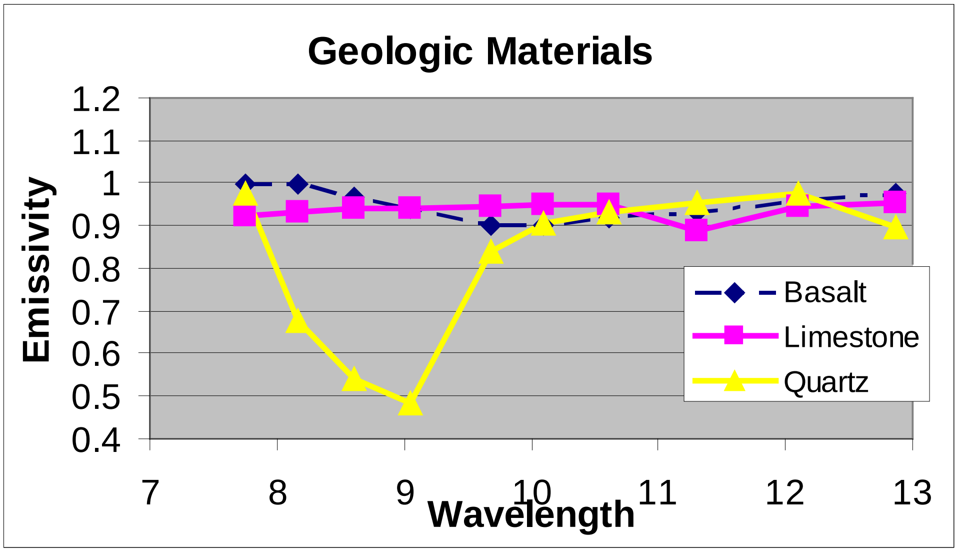
Just looking at the VIS, you would not have known that these materials have the same quartz-rich bulk composition as they are not the same color. As one has a small percentage of iron oxide and the other doesn't, they do not appear the same color in the visible.

6. *Which material has the small percentage of iron oxide from question 5? Look at the reflectance image.*

7. *The fact that the bulk composition is the same, but the materials have very different spectra in the VIS/NIR/SWIR region is an example of what characteristic of the VIS/NIR/SWIR region?*

✓ *Make several band combinations in the TIR image.*

8. *Would you say the color differences between materials(excluding quartz) in your band combinations are mostly:*
    a. *Vibrant*
    b. *Moderate*
    c. *Washed out/Grey*



9. *Explain why the color variation looks this way in the TIR by comparing the VIS/NIR/SWIR spectra you took with the TIR emissivity spectra shown to the right.*

Quartz shows up so well in the TIR image because it has one of the deepest absorption features in the TIR and is a mineral that can occur in abundance.

However, most materials have emissivities between .8 and 1.00, resulting in bands that are highly correlated and thus have little contrast. We use a decorrelation stretch technique to enhance the small differences between emissivities and create bands that are highly uncorrelated. This is a technique we discuss in the advanced class, but I wanted you to see how much information is in TIR data after it is processed.

✓ *Open the decorrelation stretch 743 image (lakemead_TIR_743_dcs.img[4])*

10. *What color are the quartz rich materials?*

✓ *Is this the same color as your answer to question 4?*

One of the advantages of the decorrelation stretch is that it enhances contrast while retaining colors close to the original band combination. A decorrelation stretch can be used on any image; if you want to try a DCS, search for the tool under the Help tab.

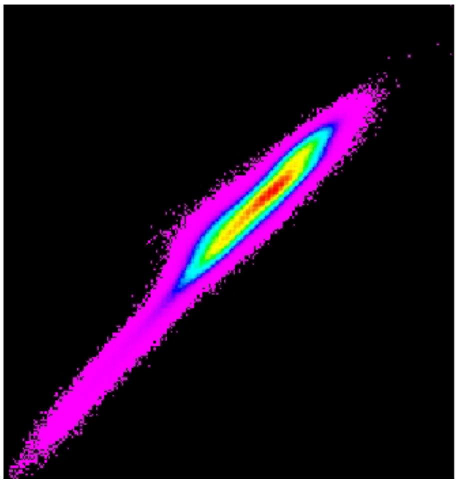
- ✓ *What color is the limestone in the DCS image?*
- ✓ *What color are the basalts in the DCS image?*

The MASTER (743) is a classic band combination. As biologists love the Landsat 432 combination for highlighting vegetation always in red, geologists love this TIR combination because rock types appear in predictable colors. In this combination:

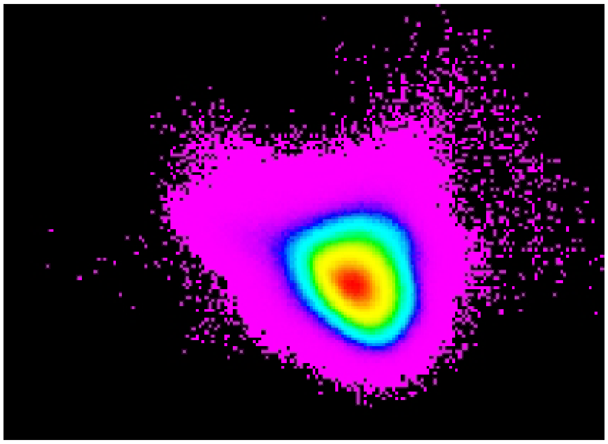
- Quartz rich rocks are red
- Mafic rocks are blue—e.g. basalt
- Metamorphic rocks are purple
- Limestone rocks are green

The DCS stretch works by reducing the correlation between bands, thus creating more contrast. Below are the Feature Space images of Bands 4 and 3. One is of the Original TIR bands and one is of the decorrelation stretch.

11. Which one represents the decorrelation image?Why?



A



B

Part 2: Discriminating Geologic Units

Now that you know more about TIR and geology, you are going to be using all wavelengths to discriminate between different geologic materials. In doing this, you will develop "rules of thumb" for when to use different wavelengths. For example, you know to use NIR if you are interested in vegetation. Now you are going to create those guidelines for Geology.

You are going to be filling out a table similar to the one below for several pairs of surface materials. Enter a YES in the table if you can discriminate between the two materials (i.e. they look different enough that you can tell them apart) or a NO if they look the same. A NO entry indicates that if you wanted to map these materials you would not use that region of the EM spectrum.

Amethyst vs. quartz example

	Visible	TIR
Amethyst vs. Quartz	YES	NO

In class we discussed, that clear quartz "looks" different from purple Amethyst in the visible because Amethyst contains <1% iron.

12. *Provide two reasons why this small percentage of iron in Amethyst produces a difference between it and clear quartz in the VIS region?*

13. *Why do Amethyst and Quartz have relatively similar spectra and thus are hard to tell apart in the TIR region?*

Basalt vs. volcanic neck.

Let's revisit the basalt and volcanic neck that you worked with in Lab3.

Basalt in Visible wavelengths

- ✓ Can you distinguish the Basalt-Volcanic Neck from the regular basalts in the visible bands? *Enter your answer in the table below on the Turn in Sheet.*

	Visible	NIR/SWIR	TIR
Basalt vs. Volcanic Neck			

By this stage of the class, you probably went through the following steps:

- Making a true color image- establishing that the color was similar in the VIS
- Looking at the spectra of the two locations and seeing that their values in the visible bands were too similar to tell apart.

Basalt in NIR/SWIR wavelengths

- ✓ Can you distinguish the Basalt-Volcanic Neck from the regular basalts in the NIR/SWIR bands? *Enter your answer in the table above on the Turn in Sheet.*

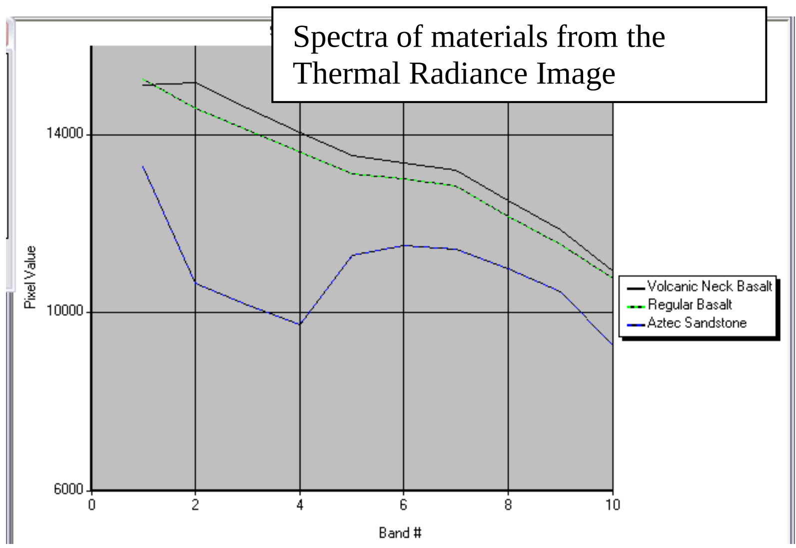
14. *What band combination using the two SWIR bands and the NIR band would make the volcanic neck magenta and the regular basalt black? Look at the spectra of the two materials.*

A fundamental difference between the Volcanic neck and the regular basalt is the larger amount of Ferrous Minerals in the volcanic neck as compared to the regular basalt. Ferrous minerals cause absorption in the NIR and reflection in the SWIR (B5) producing a positive slope in the spectra between Band 4 and Band 5.

<u>Basalt in Thermal wavelengths</u>

The Basalt and Volcanic Neck have very different amounts of ferrous iron as shown in the NIR/SWIR, but their bulk composition is very similar—they are both basalts. To determine if you can tell the two basalts apart in the TIR you would follow the same steps as in the VIS above.

A. Take spectra of the two materials and determine if they are similar (see screen shot to the right)



15. *Given the spectra taken from the Thermal Radiance image, would you expect to be able to tell the two basalts apart in the thermal region?Why? Enter in the table <u>on the Turn in sheet.</u>*

B. Confirm the two materials look the same on the TIR image.

- ✓ *Open the Lakemead_TIR_radiance image*
- ✓ *Link the TIR image with your Landsat VIS/NIR image*
- ✓ *Zoom into the area of the two basalts on the TIR image*
- ✓ *Confirm that the two materials look very similar in the TIR*

Your table should look like the one below.

	Visible	NIR/SWIR	TIR
Basalt vs. Volcanic Neck	No	Yes	No

You have discovered that:

1) the NIR/SWIR region is the best for discriminating the two basalts
2) the Visible and TIR don't work well.

If you were to map the two materials you would need to use the NIR/SWIR Region. That is because the basalts have the same "color" in the visible and share basically the same bulk composition in the thermal. However, they are differentiated by ferrous minerals in the NIR/SWIR region.

Using both the Reflectance data and the decorrelation stretch image, fill in the following tables as you did for the basalt table above. Enter a YES in the table if you can discriminate between the two materials (i.e. they look different enough that you can tell them apart) or a NO if they look the same.

Example

	Visible (321)	NIR/SWIR (456)	TIR
Basalt vs. Volcanic Neck	No	Yes	No

	Visible (321)	NIR/SWIR (456)	TIR
Aztec Sandstone vs. Colorado River Gravels			

	Visible (321)	NIR/SWIR (456)	TIR
Limestone vs. Colorado River Gravels			

	Visible (321)	NIR/SWIR (456)	TIR
Aztec Sandstone vs. Volcanic Neck			

From filling in the tables above, you can answer the following questions.

16. *Both the Aztec Sandstone and Colorado River Gravels are quartz rich material; therefore they look the same in the* ***VIS NIR/SWIR TIR****. The Aztec Sandstone has a small percentage of iron oxide, so it is easily distinguished from the Colorado River Gravels in the* ***VIS NIR/SWIR TIR****.*

17. *The Colorado River Gravels and the limestone are both* ***BRIGHT DARK*** *in the VIS. However, you know they have different bulk compositions because:*

After completing Labs 3-5, create your own “rules of thumb.” I am not looking for you to tell me which bands are good at detecting “Colorado River Gravels,” instead I am looking for more generic physical properties like “Quartz rich.”

18. *I would look at the visible bands if I was trying to detect/differentiate:*

19. *I would look at the NIR/SWIR bands if I was trying to detect/differentiate:*

20. *I would look at the TIR bands if I was trying to detect/differentiate:*

Challenge Question:

Using both the reflectance and TIR images, which of the following is true of the gypsum location on the image on page 1:

a) It has a lot of ferrous iron
b) It has a lot of clay
c) It is mixed with a lot of vegetation
d) It is mixed with a lot of quartz

21. Explain your selection and why you rejected each of the other options.

Bonus Question:

Create a new three band image:

1. Band 1 displays ferrous iron rich materials as dark
2. Band 2 displays clay rich materials as dark
3. Band 3 displays quartz rich pixels as dark

Bonus Question. Provide a print screen of your new (1,2,3) image with gypsum circled on it.

References:

1. Source for this data set was the Global Land Cover Facility, www.landcover.org. Landsat Image downloaded from Global Land Cover Facility web site. http://ftp.glcf.umd.edu/index.shtml
2. Master Image is used with permission of Simon Hook, JPL. Original data can be found at: http://masterweb.jpl.nasa.gov/ This image was produced using WinVicar Software to extract the TIR bands and convert DN to Radiance.
3. Decorrelation stretch of Master imagery using WinVicar Software.

Name_____________________________

Lab5---Part1 and Part 2

<u>Authorized Resources:</u> Any supplemental materials (ex, class notes, book, ERDAS help menu, internet). You may discuss these questions with anyone, but the answers you provide should be your own. You need to create your own data and derivative products asked for in this lab. Any discussions or resources beyond your notes or textbook should be documented.

Part 1

<u>D1. Turn in a print screen of your spectra.</u>	
1. *The pixels in this image are in radiance. What two physical properties of a surface material control the amount of radiance emitted?*	
2. *Would the Aztec Sandstone have the same spectra on an image taken on a different day? Why?*	
3. *Which mineral (quartz, biotite or olivine) has the strongest Si-O bond? Why?*	
4. *If you created a MASTER (743) image, what color would quartz rich materials appear? (Use the table of band wavelengths above)*	
5. *Which two materials listed at the beginning of the lab appear to be quartz rich?*	
6. *Which material has the 5% iron oxide from question 5?*	
7. *The fact that 95% of the bulk composition is the same, but the materials have very different spectra in the VIS/NIR/SWIR region is an example of what characteristic of the VIS/NIR/SWIR region?*	

8. *Would you say the color differences between materials(excluding quartz) in your band combinations are mostly:* a. *Vibrant* b. *Moderate* c. *Washed out/Grey*	
9. *Explain why the color variation looks this way in the TIR by comparing the VIS/NIR/SWIR spectra you took with the TIR emissivity spectra shown to the right.*	
10. *What color are the quartz rich materials?*	
11. *Which one represents the decorrelation image?Why?*	

Part 2

12. Provide <u>two</u> reasons why this small percentage of iron in Amethyst produces a difference between it and clear quartz in the VIS region?	
13. Why do Amethyst and Quartz have relatively similar spectra and thus are hard to tell apart in the TIR region?	

	Visible	NIR/SWIR	TIR
Basalt vs. Volcanic Neck			

14. What band combination using the two SWIR bands and the NIR band would make the volcanic neck magenta and the regular basalt black? Look at the spectra of the two materials.	
15. Given the spectra taken from the Thermal Radiance image, would you expect to be able to tell the two basalts apart in the thermal region?Why? Enter in the table <u>on the Turn in sheet.</u>	

	Visible (321)	NIR/SWIR (456)	TIR
Aztec Sandstone vs. Colorado River Gravels			

	Visible (321)	NIR/SWIR (456)	TIR
Limestone vs. Colorado River Gravels			

	Visible (321)	NIR/SWIR (456)	TIR
Aztec Sandstone vs. Volcanic Neck			

16. *Both the Aztec Sandstone and Colorado River Gravels are quartz rich material; therefore they look the same in the* ***VIS NIR/SWIR TIR****. The Aztec Sandstone has 5% iron oxide, so it is easily distinguished from the Colorado River Gravels in the* ***VIS NIR/SWIR TIR****.*	
17. *The Colorado River Gravels and the limestone are both* ***BRIGHT DARK*** *in the VIS. However, you know they have different bulk compositions because:*	
18. *I would look at the visible bands if I was trying to detect/differentiate:*	
19. *I would look at the NIR/SWIR bands if I was trying to detect/differentiate:*	

20. I would look at the TIR bands if I was trying to detect/differentiate:	
21. Explain your selection and why you rejected each of the other options.	
Bonus Question. Provide a print screen of your new (1,2,3) image with gypsum circled on it.	

Documentation Statement:

Extra Credit: Corrections to the Lab?