Planetary Geology **Name** _____

WARFORD RANCH VOLCANO, ARIZONA, FIELD EXERCISE

Ronald Greeley and Shelby Cave

Figures 1 and 2 should be inserted "face-to-face" to enable comparisons.

1.0 Introduction

This field trip is designed to acquaint the participant with some fundamental aspects of general geology, volcanology, and the kinds of observations that are made in "real time" in the field by humans. While jargon and specialized vocabulary are kept to a minimum, some terms are unavoidable. The field area is west southwest of Phoenix on paved roads and can be reached in about 1.5 hours. Warford Ranch volcano is a "low shield" that is one of some two dozen structures that comprise the Sentinel-Arlington Volcanic Field (SAVF), but is the smallest of the volcanoes, enabling it to be studied in about a day.

The exercise is designed to be self-discovery with the help of a guide who will walk you through the field. If you don't "catch" the answers, be sure to ask. If the concepts that are behind the answers are unclear, ask for an explanation. We have plenty of time to cover the fundamentals.

2.0 Overview

Arizona includes three physigraphic provinces: the ***Basin and Range, Colorado Plateau,*** and the ***Central Highlands*** (which is a transition zone between the other two provinces). All of southern Arizona, including Warford Ranch volcano (the subject of this trip) and the journey to the field area are within the Basin and Range province. This province is characterized by mountain ranges uplifted by faults and separated by valleys. Most of the ranges trend NW-SE and are composed of rocks as old as 1.7 Ga (billion years; Precambrian Era). Much of the faulting that formed the province occurred at about 15 Ma (million years). The valleys are partly filled with sediments derived from the mountains and rivers, and can be thousands of meters thick.

The field trip is within the ***Sonoran Desert***, characterized by saguaro *(sah-waur-oh)*, barrel, cholla *(cho-ya)*, and other cacti, plus mesquite, palo verde, ocatillo *(oca-tee-yo)*, and creosote bush.

3.0 Getting to the field area

Find your way to I-10 South toward Tucson and travel about 10 miles south of Phoenix Sky Harbor airport; take **Exit 163** off the interstate onto Arizona Highway 347 west where the road log begins.

Mileage

0.0 Intersection of I-10 and AZ 347; go west (right) toward *Maricopa*

The range to the west is *South Mountain*, formed as a special type of geologic feature known as a *metamorphic core complex*. It includes Precambrian (1.7 Ga) granites and metamorphic rocks that were intruded by magma at about 25 Ma, leading to additional metamorphism (the "core complex") and deformation of the overlying rocks. The structural fabric of the core complex trends SW-NE, which is orthogonal to most of the mountains in the Basin and Range.

1.8 *Huhugam Heritage Center* (Native American) on the right

7.0 (milepost 182) *Gila River* bridge (where's the river!?)

The *Gila (hee-la) River* drains much of southern Arizona and flows (when there is water) northwest where it merges with the *Salt River* about 25 km west of Phoenix. The Gila River then flows westward through our field area and joins the Colorado River near Yuma, Arizona.

14.4 Junction with AZ Highway 238 (Smith-Encke Road), **turn right**

27.5 *Mobile community school*; the tan hill to the right in the distance is the Phoenix garbage dump.

The mountain range to the north is *Sierra Estrella*, composed mostly of Precambrian schist; the southern part of the range (closest to our road) is composed of Precambrian granite. Typical of the Basin and Range; these mountains trend NW-SE.

30.2 (milepost 28) entering the *Sonoran Desert National Monument*

The road passes through the NW-SE trending *Maricopa Mountains*, composed mostly of Precambrian granites. Much of the surface is covered with fine gravel and coarse sand, called *grus*, which is the weathered product of granite. Many of the rocks throughout the Basin and Range have a dark surface called *desert varnish*, a manganese-rich coating formed by dust that settles on the rocks and interacts with dew, with reactions possibly aided by biologic processes.

53.4 Junction with AZ Highway 85, turn left toward *Gila Bend*; follow signs to Business Route I-8 through Gila Bend.

Gila Bend is named for the "dog-leg" course of the river, which makes an abrupt (nearly right-angle) shift from its north-to-south path to the west.

56.1 Intersection with I-8; take I-8 west toward San Diego

The *Gila Bend Mountains* are visible north of the community of Gila Bend and consist of Tertiary and Quaternary volcanic rocks overlying Precambrian granite and metamorphic rocks, all of which are heavily eroded. As we travel west along I-8, the dominant features visible in the

Gila Bend Mountains are *Woosley Peak* (east, or right-hand side) and *Bunyan Peak* (west, or left-hand side).

68.5 Exit 102, Painted Rock Road / Petroglyph site, travel north (right from I-8) on Painted Rock Road, passing through cotton fields; watch for egrets along the canals

69.4 Cattle feed-lot on the right

To the west (left of the road) are the *Painted Rock Mountains*, composed of Tertiary rocks dated at 20-25 Ma, including basalt, andesite, rhyodacite, and granodiorite rocks. At the north end of this range, the Gila River passes through a *water gap* between the Painted Rock and the Gila Bend Mountains.

79.3 Bear left at "fork" in the road toward Painted Rock campground/picnic site

79.8 Turn left on gravel road into Painted Rock Petroglyph site and park in picnic area; *lock the vehicles*

4.0 Orientation

This is the last rest-stop until the end of the field exercise when we return to this picnic area. The picnic tables under the ramada provide the opportunity to:

1) Discuss the *Sentinel-Arlington Volcanic Field* (SAVF) and set the context for the *Warford Ranch volcano*; note the *Painted Rock shield volcano* visible in profile to the southwest;

2) Outline some basic geology and the rocks and minerals that we will see;

3) Examine the *Digital Orthophoto Quadrangle* (Fig. 1) of the field site and compare with the *Thermal Infrared Multispectral Scanner* (TIMS) image (Fig. 2);

4) Outline the field exercise

Some general questions to keep in mind regarding the geology of this, or any, volcanic site:

1. How thick are the lava flow(s) that compose the shield volcano? If there is more than one flow, was there substantial time between their emplacement(s); justify the answer.

2. How much erosion has occurred on the surface of the shield; what is the basis of your estimate?

3. What is the reason for the different appearance of the summit area in comparison to the flanks of the shield, as seen in the remote sensing data?

4. Does the current outline of the shield seen in over-head view represent the full extent of the volcano; why or why not?

5. What is the composition of the rock upon which the shield was emplaced, and what is the nature of the "contact" (the interface) between the lavas of the shield and the underlying rock?

6. Does the surface of the shield represent the texture of the lava flow(s) at the time of emplacement; why or why not? If you have seen fresh lava flows in Hawaii or elsewhere, do a comparison with the Warford Ranch lava flows.

7. Is there evidence of water interaction with the lava; if so, what is the evidence?

5.0 The field exercise

Return to vehicles and travel back toward I-8 on Painted Rock Road ~1.5 miles and park off the road.

Stop 1 (Optional)
Examine the rocks exposed in this area. Identify the primary minerals:

Name this rock:

Continue on Painted Rock Road toward the Interstate to the field site parking area near milepost 8 (at about mile-post equivalent 8.4) on the north side of the road. Vehicles will remain here for the field exercise; take lunch, water, field exercise, cell phones and vehicle keys with you.

Stop 2 (Parking area)

Orient the images to the terrain. Examine the rocks in this area. Find an "outcrop" (rocks formed in place) and examine "fresh" rocks (hit them with a hammer!) Name the rock:

Is there evidence of alteration of the rocks?

Stop 3 (Hill across the road opposite the parking area)

Make a "traverse" (walk toward) the hill and note the types of rocks that are encountered. Note which rocks are "float" (loose rocks on the surface that have migrated down-slope from above) and those that are exposed in outcrops.

Name the "float" rocks

Name the outcrop rocks

Describe the “weathered” surfaces of the rocks versus “fresh” (use hammer) appearances of the rocks.

Continue the traverse to the first small cliff and describe the appearance of the outcrop and the rocks in the hill. Relate the “float” rocks to the rocks in this outcrop.

Stop 3 provides a good perspective for viewing the ***Warford Ranch low-shield*** (LS) volcano. Find a comfortable rock to sit on and then sketch a general *profile* of the volcano; are the slopes in profile uniform, or do some slopes appear steeper? Consider the reasons for the slopes that you observe.

Orient the two images of the field area to the terrain before you. *Geologic maps* provide the context for most geoscience investigations of planetary surfaces. Use tracing paper and make a simple geologic sketch map of the area, using the Color-Near IR Digital Orthophoto Quadrangle (Fig. 1) and the TIMS image (Fig. 2) as the base. Draw lines (called “contacts”) around the exposures of apparently similar rocks seen on the images. Note the differences in the general color “tone” of the surface and other characteristics of the terrain that you see across the road and compare to the images and your map.

From the sketch map that you produce, predict that rock types you might find on and around the Watford Ranch LS.

Observe the reddish hill to the left (south-west) of the summit of Warford Ranch volcano. Pose some hypotheses regarding the origin of this hill. The hill is **Stop 5** and we will have a chance to “field-test” your ideas.

Traverse to Stop 4

We will now retrace our path back across the road (watch for traffic!) and walk down into the arroyo (small gulley) to the northwest (left) of the parking area. Remember the rock type at the parking area and the rock type at **Stop 3**. A “Holy Grail” in field work is the *contact* (the boundary between two different types of rock). On this traverse, find the contact between the two different types of rocks that you have seen and compare with your sketch map. Which of the two rock types is older; how can you tell?

Stop 4 (Floor of the arroyo)

The floor of the arroyo has scoured the bedrock and gives good exposures of the rock textures. Describe what you see, especially with regard to the *rhyodacite.*

Traverse to Stop 5 ("Red Hill" to left of volcano summit)

Describe the rocks and remember the "Holy Grail" in field work. What is the origin of the white material on the surface of many rocks? What is this white material called?

Note the loose black and white rocks on the surface and how they fit together so closely; what is such a surface called?

Explain how such surfaces might form?

Stop 5 ("Red Hill")

This is the hill that you could see from **Stop 3**. Test your ideas about this hill and record your answer.

How might the observations here be applied to mapping other parts of the remote sensing data?

Numerous small white dots are visible on the image. What are these?

Traverse to the summit of Warford Ranch LS

Walk toward the summit of Warford Ranch LS. Look back toward "Red Hill" and note the difference in color "tone" of the surface, the vegetation, and the amount of caliche. Offer some possible explanations for the differences.

Near the summit, note the small red rocks; what is this material called?

What *style of eruption* produces the small red rocks?

Note the ~meter-high "wall of basalt." What is this feature called, how did it form, and what is its relation to the small red rocks?

Explain how this feature (the wall of basalt) can be used to estimate the amount of surface erosion from the summit area?

Stop 6 (Summit area)

Was Warford Ranch LS built exclusively from lava flows?

Was there more than one eruptive center ("vent") in the summit area?

What might account for the steeper slopes in the summit area?

Departure from summit

After the field work, explain how your impression of the site differs from your impression before the field work based on the images.

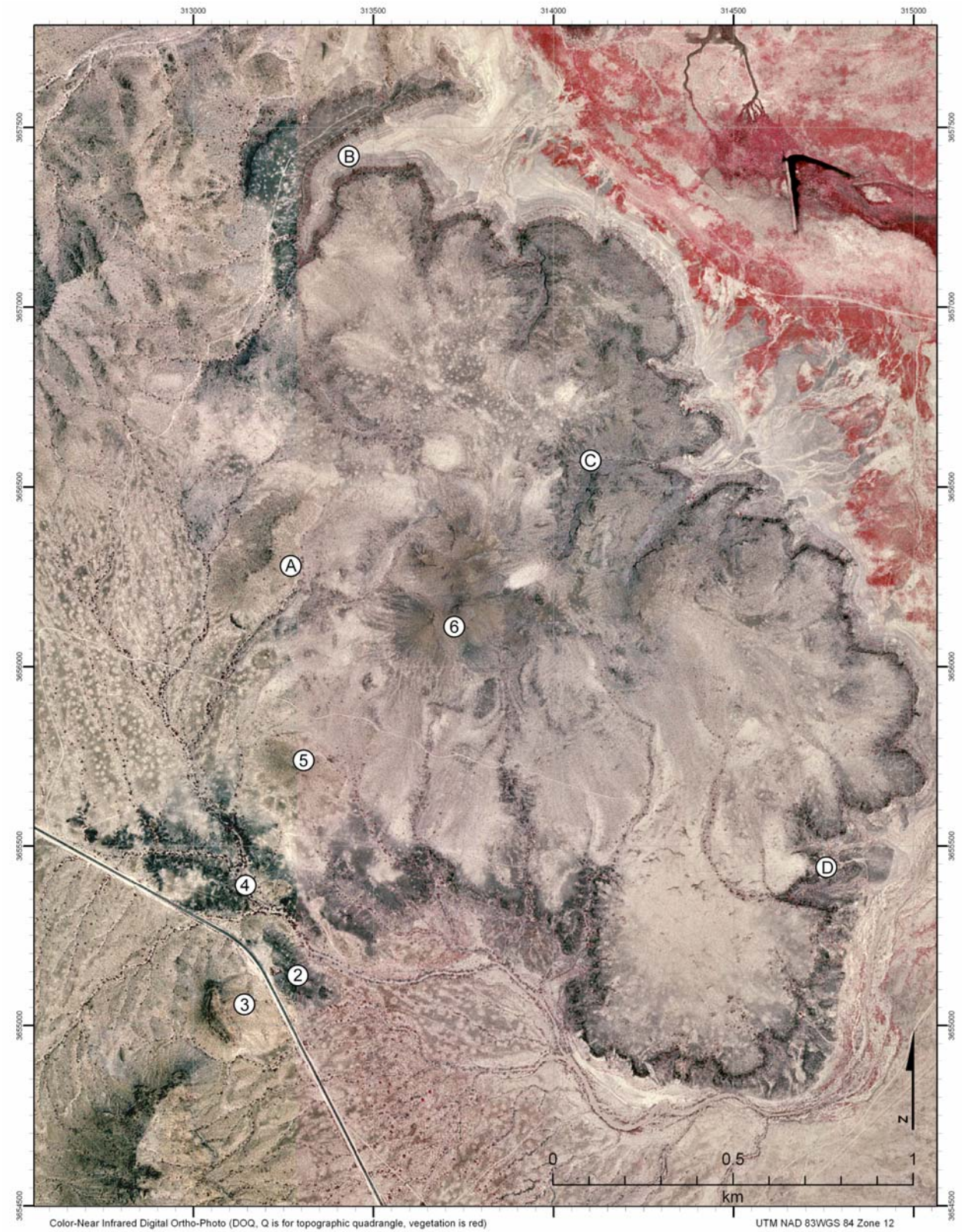

Figure 1. Digital Orthophoto Quadrangle of the Warford Ranch low shield, showing numbered stops and options (letters) for the return to Stop 2. The historic Butterfield Overland stage route is visible as the white line extending west northwest from point "D."

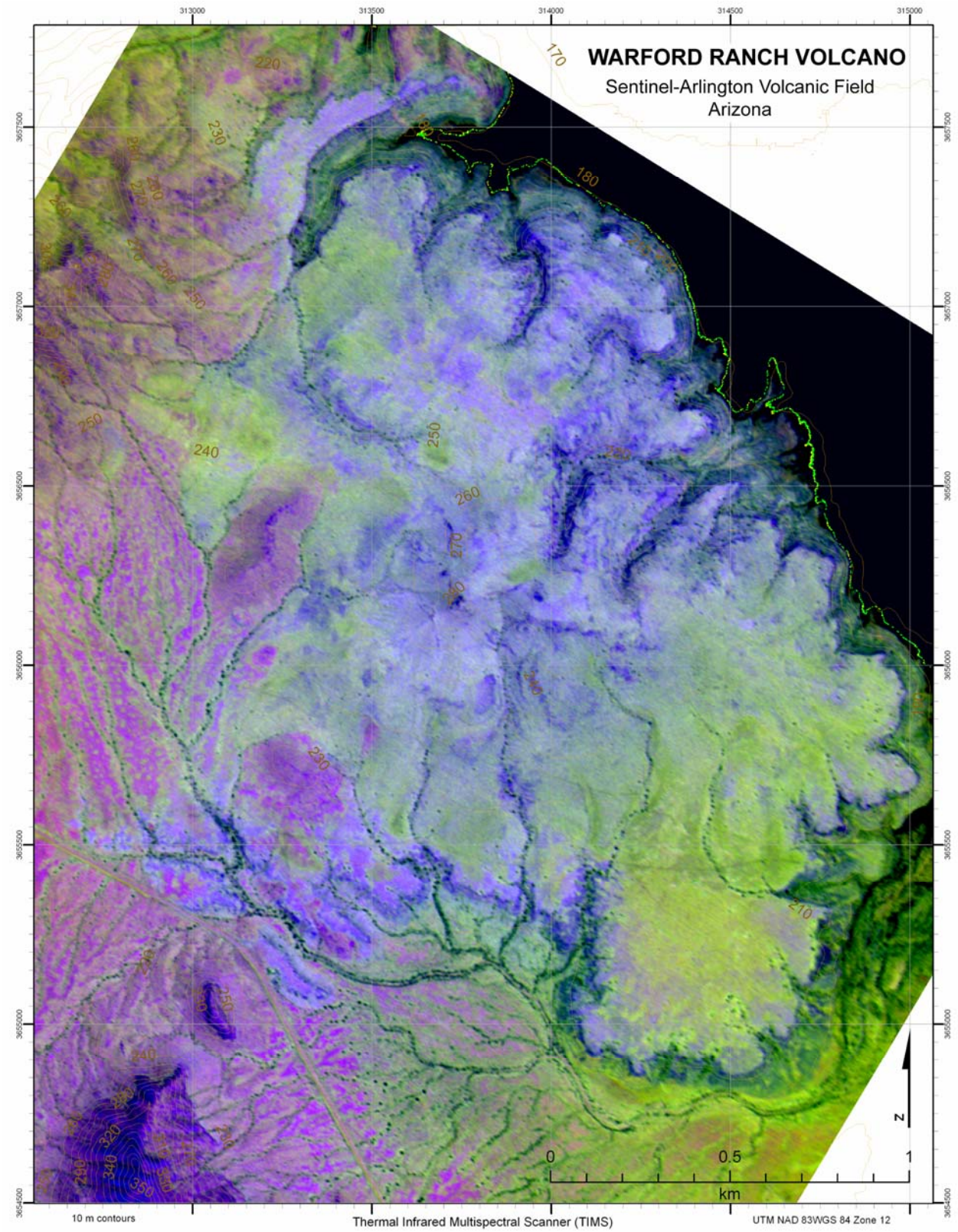

Figure 2. Thermal Infrared Multispectral scanner image of Warford Ranch.