North Table Mountain Field Trip for Colorado Scientific Society

WHEN (8:00 AM, Sat. April 2005 – By Harald Drewes

Background – Table Mountain (NTM) lies immediately NE of downtown Golden, Colorado and N of the Coors Brewery. It is the northernmost of three hills in the Denver area that lie E of the Rocky Mountain Front Range and the Dakota Hogback.

The main geologic features of NTM have been known since the early surveys of the West (LeConte, 1868; Hayden, 1873), and have been frequently studied by the staff and students of the Colorado School of Mines. Additionally, Van Horn (1972) mapped NTM, part of South Table Mountain (STM) and the Ralston "Dike" area, and Scott (1976) mapped the remainder of STM and Green Mountain (GM). The objectives of these mapping studies focused on stratigraphy, paleontology, engineering geology and surficial deposits. My contributions focused on structurally geology and petrography. A few adjustments were also made to the maps.

WHERE

The plan of this field trip is to cross the western part of the NTM mesa. We will ascend by trail and an old quarry haulage road on the west flank and descend on or near a service road for a communications facility on the NW flank. The area of that facility should make a good lunch stop. Meet at the Jefferson County parking lot on the W side of the mesa (from CO Hwy. 93 take Pine Ridge Road E one block, then turn onto Wyoming Street). We'll arrange a car shuttle and end up at the Jeffco Open Space gate on 58th St., about 0.5 km E of CO Hwy. 93.W

On this field trip we'll see some new (?) geologic features, and "arm-wave" in some others, particularly those on STM and the Ralston "Dike" area. We'll see faults, open folds, a tumulus ridge, a newly identified lava flow, and a low dome on STM.

The lava flows are intercalated in the Paleocene part of the Denver Formation (TKd). The low area W of Hwy. 93 is chiefly underlain by alluvial terrace deposits, beneath which is the Late Cretaceous Pierre Formation. This formation is mainly made up of mudstone that is more than 6,000 ft thick. The ridge W of the lowland is underlain by the Late Cretaceous Dakota Group, made up mainly of moderately indurated sandstone, a few hundred of feet thick. Other Cretaceous formations are of little consequence on this trip. The lava flows are 63-64 my old (Obradovich, 2002).

The Golden Fault lies W of the mesa and mostly also W of the highway. It was active through Late Late Cretaceous to Early Paleocene (Green Mountain, member 4) time, probably peaking toward the end of this time span, to judge from the age of the coarsest and thickest piedmont deposits. One shred of evidence suggests that locally there was renewed movement on the fault during Late Pleistocene time. While the fault and its major branches followed the steeply inclined Pierre Formation in this area, in cuts gradually down-section to the S, with the W block having moved up relative to the E block.

Trip Description – Leave parking lot on trail to a large water tank and continue upward S of the tank and then N onto old haulage road to a quarry. Ascend the road a few hundred meters.

STOP 1: Alongside the road are large blocks of a lava flow, probably not from the overlying end of a channel flow 1; it is a good place to get acquainted with the shoshonite porphyry. Phenocrysts make up 15-20% of the rock and are of 1-4 mm size. These are set in a mostly blocky groundmass with minor felty overtones, and commonly in the 0.2-0.5 mm size. The major minerals are andesine plagioclase (near white and tabular), augite pyroxene (black and tabular) and olivine (greenish black and somewhat rounded-blocky). Accessory minerals include magnetite and apatite. Additionally, most rocks contain interstitial orthoclase and biotite. Secondary minerals include alteration products and in some rocks also zeolites. Shoshonite is a fancy name for potassium-rich basalt.

The lava flows are numbered, in rising sequence, by Van Horn (1957). His scheme is followed in this study; thereby the newly identified flow gains the label of flow 2 and the mesa-capping flows are now numbers 3 and 4. From limited petrographic evidence, flow 1 may comprise two kinds, the older of which is provisionally called flow 1a. More about this is offered at stop 9. In hand specimen all flows and intrusive rocks look alike. Microscopic study, however, shows subtle differences in texture or composition.

Near the water tank, below, and on our way upward to the next stop we pass small outcrops of the Denver Formation, a weakly indurated siltstone and sandstone, as well as some mudstone and pebble conglomerate. A tuffaceous component is probably present in the nearly white beds. All coarse clasts are andesite except near the lava flows where some shoshonite porphyry clasts are also present. Elsewhere some lenses of cobble conglomerate and even fewer of boulder conglomerate are also found, but they make up less than 5% of the formation in this area.

In case of uncertain weather call Drewes at (303) 237-0748

Most beds are stream deposits; some are mudflow units. What can be inferred about the source and local relief from such rocks?

STOP 2: Farther up the haulage road are a seep and some trees. In outcrop above the road is a wedge of clastic beds beneath flow 4 (and presumably above flow 3). Such intra-flow deposits occur at intervals around NTM but have not been seen on STM. Here the thickest part (about 10 m thick) of the wedge ends abruptly to the N and it appears to thin out to the S beneath the artificial fill of the haulage road and talus. Most beds are sand or granule sized, but some are of pebble and cobble conglomerate. What happens at the N end of this wedge? Then what is the age relationship between the inferred feature and the sedimentary wedge? Does the presence of the seep here make sense? [*infer a fault*]

Continue up the haulage road to the mesa top, passing an outcrop of columnar jointed lava flow 4. Note particularly the flow foliation cutting across these columns. This foliation has been useful in interpreting structures and in understanding geomorphic details; it has also been utilized in various quarrying endeavors. At the mesa crest do not head into the quarry but head for the low rise to the NE. On this stretch are seen bare rock surfaces on which the hexagonal cross-sections of the columns are readily apparent.

STOP 3: From the low rise many features can be seen at a distance and one noteworthy feature lies underfoot. To the S and across Clear Creek is STM on which both lava flows 3 and 4 are found. However, flow 4 is less widespread than previously mapped. While once thought to underlie the north half of the mesa, this study shows it to be restricted to the W and NE flanks of the north half. Most of the N half of STM is underlain by flow 3 in a low dome, which is shown by the flow foliation. Along a zone extending S from the notch just E of Castle Rock to a minor notch near the east end of the northern mesa edge only a single flow makes up the cliff. Although the top of the dome is rather flat, along its W margin is a zone of foliation dips that locally exceed 30 degrees W; along the NE margin the flows dip are about 10 degrees E or NE. The mesa flanks, then, have remnants of rather narrow belts in which flow 4 is found, and they do not rejoin to the S. The inference is that, upon reaching the dome, flow 4 split into two channels. The W channel is fairly straight and a bit more than a kilometer long, whereas the NE channel edge is sinuous, as if it was earlier a stream channel and about the same length. On the E and SE margins of the dome are 6 or 7 smaller structural noses, each about 100 m wide and 200 long, well defined to the SE but merging gradually with the main dome to the NW. Apparently this irregular drop off had been had been viewed as the end of flow 4. What might have formed this low flat-topped dome? Are the small noses explainable?

Beyond STM is Green Mountain, underlain by weakly indurated Paleocene Green Mountain Conglomerate, now divided into four members. These are old piedmont alluvial deposits that coarsen upward and that were derived from the NNW. A small outcrop of lava flow 3 was to be found on the first rise beyond the county fair grounds; unfortunately the area was suburbanized more than 10 years ago. Other reports of lava in this area have not been substantiated. Noteworthy is the fact that even were the gently SE dip of the top of STM to flatten further, the GM outcrop would lie too high. What does this imply?

Let's now turn to NTM. The general dip of the flow foliation, as indicated by the slope of the mesa top, is SE. However, at the high ground to the NE dips are 5-10 degrees SW. As a result, the mesa capping flows are warped into a broad open syncline. A similar syncline is found near the SE end of STM. Likely these folds were formed as a result of the deposits settling into the Denver Basin. The small fault seen at stop 2 and the several dozen similar faults were also formed in this way, rather than as a response to tectonic stresses.

Turn now to the rock under foot. The ridge crest lays a few tens of meters above the adjacent area, and the crest is arcuate in plan, concave to the E. About 1 km SE of the SE end of the ridge is another rise. Flow foliation adjacent to ridge and rise dip away from the crest, mostly gently but locally 20 degrees. This feature is inferred to be a tumulus, a sort of welt generated by steam that lacked the power to cause an explosion and form a maar. What might the linear crescent shaped plan of this feature mean? We'll return to this problem at stop 7. Continue N along the E side of the ridge.

STOP 4: Again, watch the flow foliation, and here also note the details of the land surface. What do you make of the scores of scallop shaped "depressions"? Are they natural or man made? If natural, how were they produced; if man made, why were they produced? [*quarrying with rock bars*] Continue NE to the communications building.

STOP 5: This site may make a good lunch stop. Fresh blocks of shoshonite porphyry are available here. There is also a fine view to the W. The Dakota Group underlies the ridge beyond Colorado Highway 93. What happens to its southern end? The old quarry at this end shows many signs of faulting. Most shear planes are steep but others are of diverse orientation in the mudstone E of the Dakota Group. The mudstone appears to have been smeared by many small faults that mark the Golden Fault. North of this site to the end of the study area the fault is inferred to divide into three (not two) branches, based on indirect evidence. Most intriguing is one shred of evidence that the western branch, herein newly proposed, was last active during Late (?) Cenozoic time. In one man-made outcrop colluvium dips about 10 degrees west toward the fault.

Fresh shoshonite porphyry blocks of lava flow 4 are present at this site, as they are at many of the foundations of the power line that crosses NTM. The upper part of flow 4 has almost everywhere (or everywhere?) been eroded. However, a red oxidized amygdular zone at the top of flow 3 provides an example of what was eroded. Inasmuch as this upper zone of flow 3 is easily eroded relative to the thicker lower columnar jointed part of the flow, it underlies a topographic bench. Pick out this bench beneath us and project it ahead of our route so far. Evidence of the upper zone of flow 3 may be harder to find on north-facing slopes on which a thicker cover of colluvium is present, so we may head to a W facing slope.

To the NW beyond the highway are some low knolls and the Ralston "Dike", or more accurately, the Ralston Plug, since at the present level of exposure the body is not tabular, but elliptical, 1 km by 2 km. Shoshonite porphyry intrusive rocks underlie these knolls and the high hill at the active quarry of the Asphalt Paving Company, and among these intrusive rocks are the sources of the lava flows. We'll return to these features at stop 7. We now head NE, past a dry (?) stock pond, and to or just beyond the power line.

STOP 6: A low ridge runs NE and below it is a slight bench that has the rubble of a flow top. The rock of the cuesta is herein seen to be flow 4, and the detritus of flow top material marks the top of flow 3. In other words, flow 4 has been eroded back from the edge of the mesa. This situation continues to the NE end of NTM, and for most of this stretch the cliff is made up of a single flow, number 3. Now head NW to a high point along the mesa edge.

STOP 7: The mesa edge here is developed in the lower part of flow 3, forming a cliff about 10 m thick. A bench on which outcrops are poor lies beneath the low cliff. Small rounded clasts (worn or weathered round ?) of pebble size are sparsely present in the colluvium on the bench. The shoshonite body below appears to be another unit than the previously known flows, and the abrupt upward ending of the zeolitized rock may be the sign of a disconformity. Should the rounded fragments have been worn round, they may be a remnant of a thin clastic deposit along this disconformity.

Before leaving this site let's return to the review of the intrusive rocks West of highway 93 that was started at stop 5. Note again to the NW the distant highest hill with the quarry. It is underlain by a rim of more resistant or harder rocks and a core of weaker ones. Fresh rim rocks are a medium gray color, whereas those of the core are browner even where well exposed in the quarry. The dominant jointing in the rim rock strikes ENE and dips steeply, whereas the main joints of the core are gently inward dipping. The core area rocks are so weak that a basin has developed on them. With a little help from man, the basin now contains a reservoir. What would the seeming lack of a recognizable contact between these rock phases imply? Petrographic study also shows that there is a subtle difference between the two rock types. Altered ("baked") Pierre Shale host rocks form a belt about 10 m wide. The Ralston Plug is seen to be a composite intrusive body, and one up which a large amount of magma passed, bringing with it sufficient heat to alter the host rock.

In the area between the composite plug and our stop 7 site are many small pods, dikes and sills (?) of shoshonite porphyry. A small plug forms the hill just NW of the junction of highway 93 and 58^{th} Street. No signs of alteration are found in the adjacent Pierre Shale. A single specimen from the SE border of this plug has an anomalously all-felty groundmass texture rather than the normal blocky texture with just a hint of the felty. At stop ~~8~~9 we'll return to this texture variation. This small plug is believed to have reached the surface. It also may be a two-phased vent. Most of the other small intrusive bodies probably did not reach the surface, although two bodies W and NW of the small plug may have done so. The small plug without altered surrounding host rocks appears to have had a small volume of magma pass through it, thus bringing less heat. Which of the plugs are linked to which flows based on this observation alone?

Two options are now offered to get down the mesa flank. Those able to head directly down the slope below site 7 will head down just W of the big cliff below. The other option is to backtrack a bit and head down the service road of the communications facility of stop 5. While this second option is a longer way, there will be no delay in pausing at stop 8, and a few key features of the stop 8 site can be explained from the road. In any case, all will rejoin on the service road below the large cliff.

STOP 8: Here the contact between the shoshonite porphyry and TKd is very steep, yet there is no sign of shearing. To the E the body of lava is thicker than to the W. On neither side of the steep contact segment does the body extend far from this large outcrop. The rock is much zeolitized and probably also has many veinlets and pockets of calcite; these are particularly abundant near the steep contact. The appearance of this body is that of a lens, or channel-filled lava flow and the step up to the W suggests that the channel had a stream terrace. The lava filled the lowest part of the channel and spilled over onto the adjacent terrace. The abundant secondary minerals likely reflect the abundance of water in the channel or its underlying sediments. The position of this channel flow immediately beneath flow 3 and not as low down as the channel flows 1, an outcrop of which is found on the E side of the gulley a few hundred meters to the E, indicates that it is a newly identified flow, herein labeled number 2.

While it is conceivable that a locally upfaulted segment unconformably beneath flow 3 could explain the relationships seen, that interpretation is more labored than inferring the presence here of a separate flow at a different horizon in the TKd. Continue down to the service road and rejoin any of the group who walked down the road.

After reviewing for the road walkers what was seen at stop 8, let's consider whether the interpretation of the origin of the arcuate tumulus ridge and that of flow 2 may be combined. Flow 2 heads under the cap of flow 3 along some southerly trend, say SW. Where flow 2 filled its channel its heat drove off the water along the gully bottom. Somewhere SW of the site of stop 5 flow 2 ended, so the channel still retained its water. Flows 3 and 4 then covered the entire lowland and the water in the lower reaches of the channel turned into steam under pressure sufficient to bow up the still hot and mobile overlying segments of flows 3 and 4. More magma of course filled in beneath this elongate welt. The arcuate trend of the elongate tumulus marks a sinuous stream channel. The gap between the tumulus ridge and low dome towards which the ridge heads might simply be a channel segment that was dryer. While at present this interpretation cannot be proven, it has a certain appeal in logic. Can anyone offer an alternative? Follow the service road N.

STOP 9: Above the service road and about 50 m beneath the base of the cliff at the top of the mesa is an outcrop of shoshonite lava. In this study the outcrop was traced farther south into the deepest gully near the power line, and almost beneath flow 2, thereby helping to distinguish the channel flows of two different levels. Petrographic study of this flow 1 (there are several flows at this level around NTM) shows it to have a felty texture like the rock from the margin of the nearby small plug. These are the only rocks of those examined with this texture, which suggests a genetic correlation and a provisional designation of flow 1a The reason for considering the correlation only provisional is that the determination is based on only a pair of specimens, whereas in all other cases correlations are backed up by four or more pairs of specimens. Continue N on the service road to 58th Street. With the completion of the car shuttle for drivers, the formal part of this field trip ends

Depending on the time of completion, the weather and the inclination of the participants, an informal extension to the trip may be arranged at such a site as a convenient Starbucks or the patio of Golden's second largest brewery. This may give us time to explore such topics as the details of shoshonite porphyry modes; the systematic variation between modes; the basis for correlating the rim phase of the small plug, core phase of the small plug, rim phase of the Ralston Plug, and core phase of the Ralston Plug, respectively, with lava flows 1 through 4; and the structural implications of volcanic features seen in the field and under the microscope. Through the span of time between the flows, the magma became increasingly richer in potassium-bearing minerals. Reaction rims are seen in all specimens, but are sparse. What was happening?

REFERENCES

Hayden, F. V., 1873, Publication of the Hayden Survey: Government Printing Office, Washington, D.C., United States, 844p.

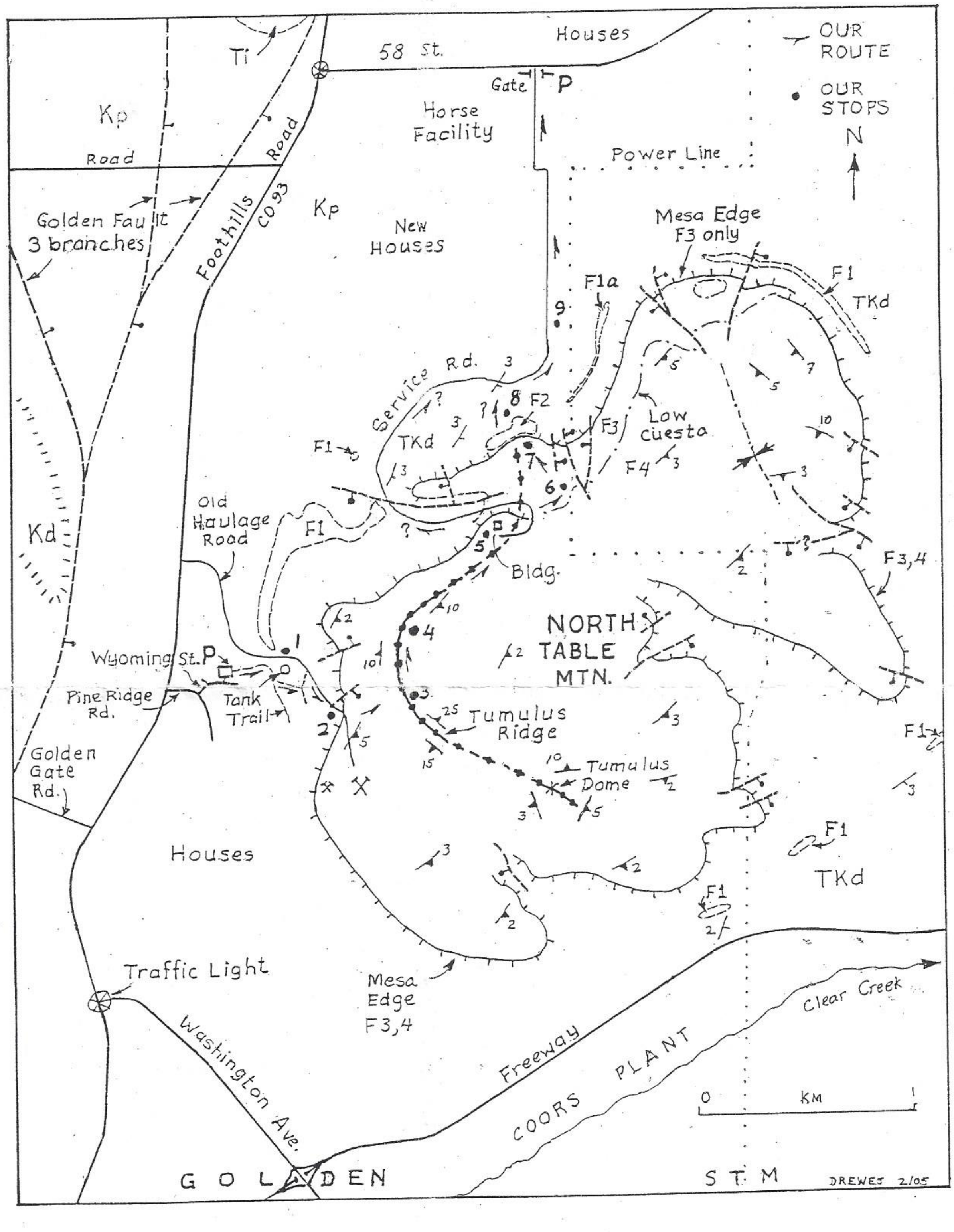
LeConte, L. J., 1868, Notes on the geology of the survey for the Union Pacific Railroad from Smoky Hill River to the Rio Grande, p.76.

Obradovich, J. D., 2002, Geochronology of Laramide synorogenic strata in the Denver Basin, Colorado Rocky Mountain Geology, v, 37, no. 2, p. 165-171.

Scott, G. R., 1976, Geologic map of the Morrison Quadrangle, Jefferson County, Colorado: U. S. Geological Survey, Geological Investigations Map I-790-A, scale 1-24,000.

Van Horn, Richard, 1957, Bedrock geology of the Golden Quadrangle, Colorado: U. S. Geological Survey, Geological Quadrangle Map GQ-103, scale 1-24,000.

1972, Surficial and bedrock geological map of the Golden Quadrangle, Jefferson County, Colorado: U. S. Geological Survey, Geological Quadrangle Map I-761-A, scale 1-24,000.



Houses
58 St.
OUR ROUTE
OUR STOPS
N
Ti
Kp
Road
Gate
P
Horse Facility
Power Line
Foothills Road CO 93
Kp
New Houses
Golden Fault 3 branches
Mesa Edge F3 only
F1
TKd
F1a
9
Service Rd.
8
F2
TKd
F1
F3
Low Cuesta
F4
7
6
Kd
Old Haulage Road
F1
5
Bldg.
F3,4
4
NORTH TABLE MTN.
1
Wyoming St.
P
Tank Trail
Pine Ridge Rd.
3
2
Tumulus Ridge
Tumulus Dome
F1
Golden Gate Rd.
Houses
F1
TKd
F1
Traffic Light
Mesa Edge F3,4
Washington Ave.
Freeway
COORS PLANT
Clear Creek
0
KM
1
GOLDEN
STM
DREWES 2/05