

Introduction:

- A 60+ mile, N70W trend of thousands of magmatic igneous intrusions run across the Northern Black Hills of South Dakota lay thousands of magmatic igneous intrusions.
- Due to gold remineralization related to these intrusions many of the larger intrusions have been mapped and documented.
 - We have located at least 3 unmapped intrusions and hypothesize that there many more small intrusions that exist unmapped.
- We know where and when these intrusions surfaced but as to how they arose remains unknown.
 - Researching these tertiary intrusions will yield many benefits towards our understanding of the Black Hills and how it formed.
- The two main goals of this research project are to:
 - Collect and compile all data regarding tertiary intrusions into one location (GIS).
 - Collect rock samples for geochemistry and petrology of the unmapped units and compare them with previously recorded units.

Geologic Background:

- The present dome structure of the Black Hills are a result of a mountain building event known as the Laramide Orogeny.
 - Between 35 million and 80 million years ago (Gries, 2003).
 - Collision between the Kula and Farallon oceanic plates subducting underneath the North American continental plate (Duke, 2005).
- Prior to the Laramide Orogeny, the Black Hills area consisted of flat laying sedimentary units on top of crystalline basement rock (refer to Fig. 1 for stratigraphy of the older units).
 - During and after the Laramide Orogeny, intrusions were rising from magma chambers at depth and were uplifting the northern hills (Gries 2003).
- Magma intruded the rock above in the form of sills, dikes, stocks, laccoliths, and some may have erupted at the surface as diatremes (see Fig. 4).
- Since the end of the Laramide Orogeny, much of the overlying sedimentary units have eroded away, revealing much of the igneous and metamorphic rock seen today (Gries, 2003).
 - Igneous rocks are usually more resistant to weathering and heavily influence the topography in the northern hills
- Past geologic work conducted by various entities has been highly beneficial towards this research.
 - Much Data remains in older theses and papers.
 - Compiling these data sets into one location will greatly help future research within the northern hills.

ERA	PERIOD	GEOLOGIC UNIT	THICKNESS (ft)	DESCRIPTION
Mesozoic	Cretaceous	Lakota Formation	35-700	Sandstones, conglomerates, minor limestones
		Morrison Formation	0-220	Green to maroon shales, thin sandstones
	Jurassic	Sundance Formation	250-450	Greenish-gray shales, thin limestones, glauconitic sandstones
		Gypsum Springs Formation	0-45	Primarily gypsum, some red siltstones
	Triassic	Spearfish Formation	250-700	Red sandy shale, soft red sandstone and siltstone, gypsum lenses especially near base
Permian	Minnekahta Limestone	30-50	Massive gray, laminated limestone	
	Opeche Formation	50-135	Red shales and sandstones	
Paleozoic	Pennsylvanian	Minnelusa Formation	350-850	Yellow to red sandstone, limestone, and anhydrite, red shale near base
	Mississippian	Madison (Pahasapa) Formation	300-630	Massive light colored limestone (dolomite in parts), caves common towards top
	Devonian	Englewood Formation	30-60	Pink to buff limestone, local shale at base
	Ordovician	Whitewood Formation	0-60	Buff dolomite to limestone
		Winnipeg Formation	0-100	Green shale, siltstone
PreCambrian		Deadwood Formation	10-400	Massive buff sandstones, thin shale layers, some limestones, and some lime clast conglomerates
		Metamorphics, igneous		Schists, slates, phyllites, quartzites, and granites

Figure 1: Shows a stratigraphic column of the Black Hills starting at the Precambrian period and ending at the Cretaceous period. Much of the younger rock in the northern Black Hills has eroded away, revealing rocks as old as the Deadwood formation and many of the younger igneous intrusions that cross-cut them.



Tertiary Intrusions Within the Northern Black Hills

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BLACK HILLS
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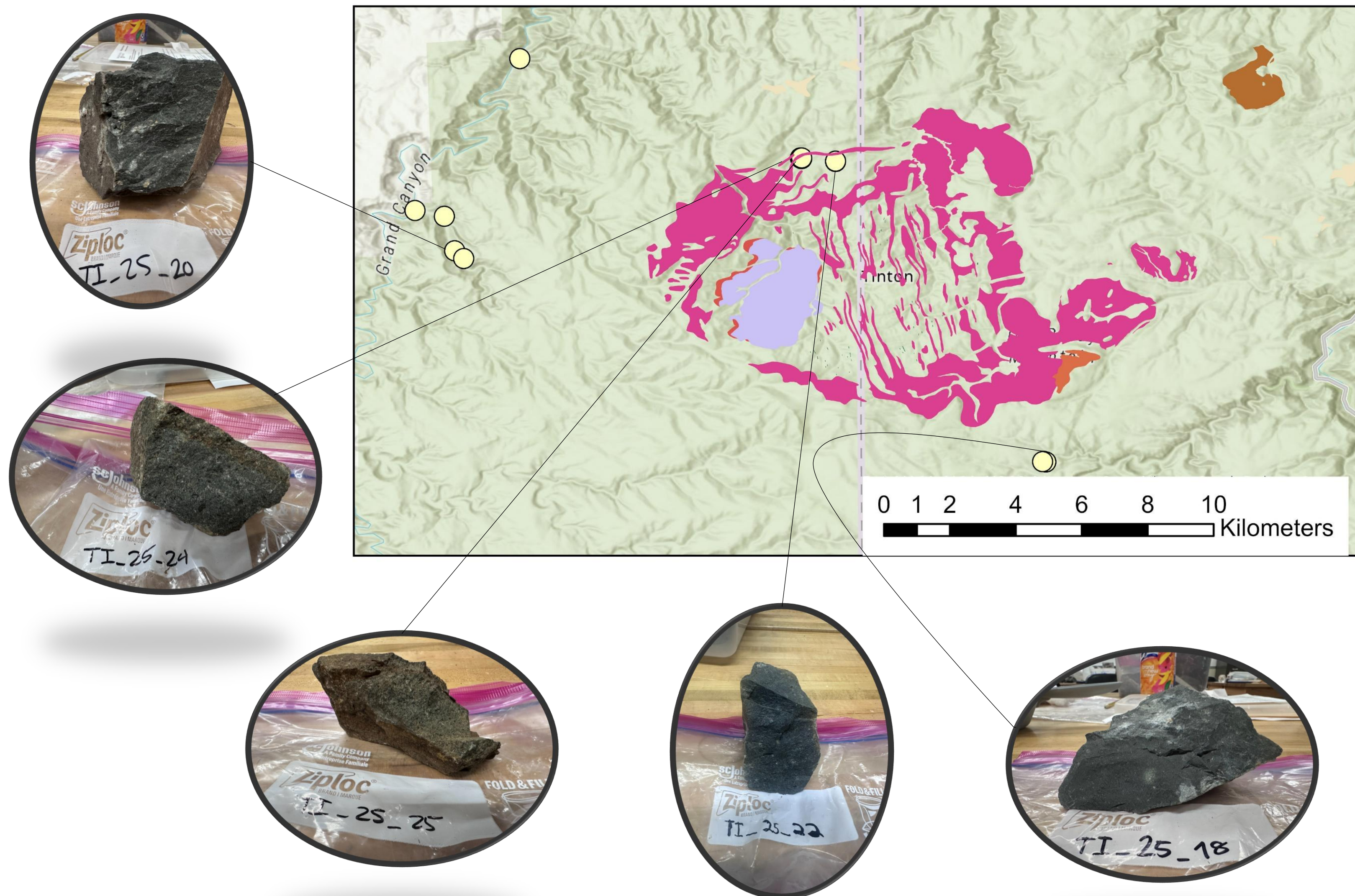
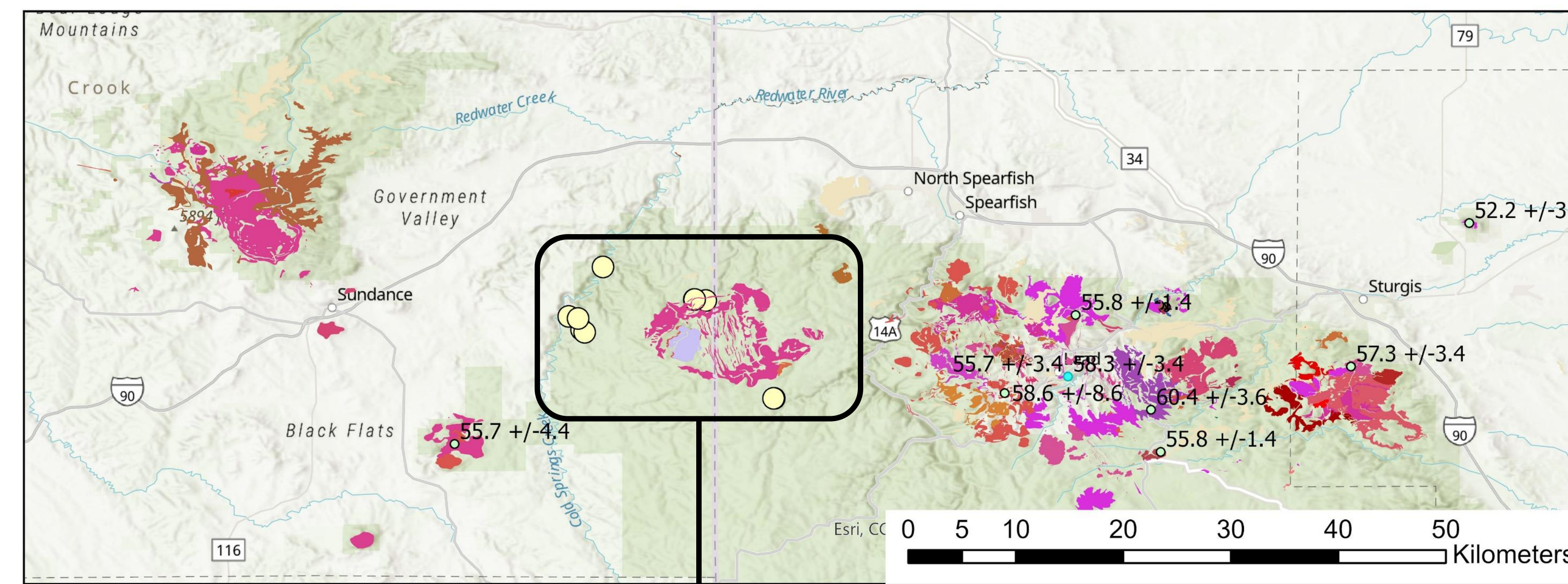


Figure 2 (above): Shows a broader scale of each of the igneous units throughout the northern Black Hills. This figure includes the ages of each unit and shows an evolutionary trend of the intrusions as they were rising from their respective magma chambers.

Figure 3 (left): Shows a close-up view of the Tinton area along with every location we collected an igneous intrusion sample. This figure also illustrates the physical hand samples collected and ties them to the location they were discovered. While nearly all previously mapped data of the Tinton area suggests these intrusions are of Trachytic origin, the samples collected appear to be aphanitic, more dense, more mafic, and contained fewer feldspars. This leads to the hypothesis that the samples collected in the Tinton area are more lamprophyre and pyroxenitic like.

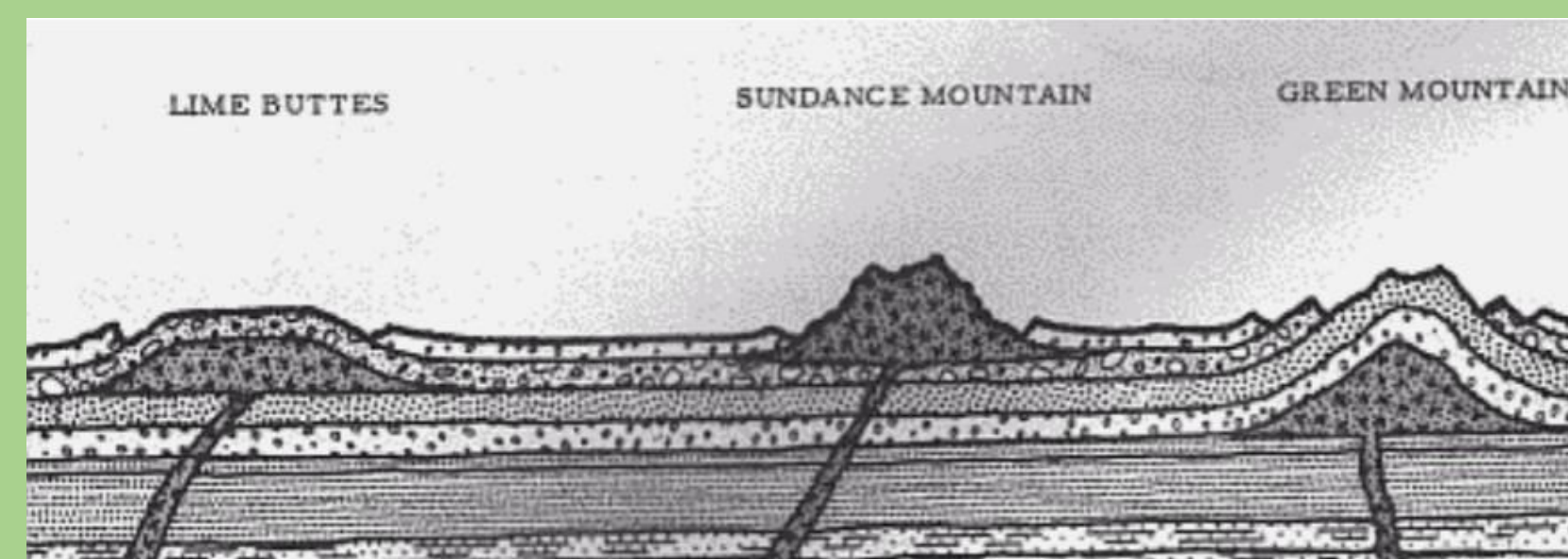
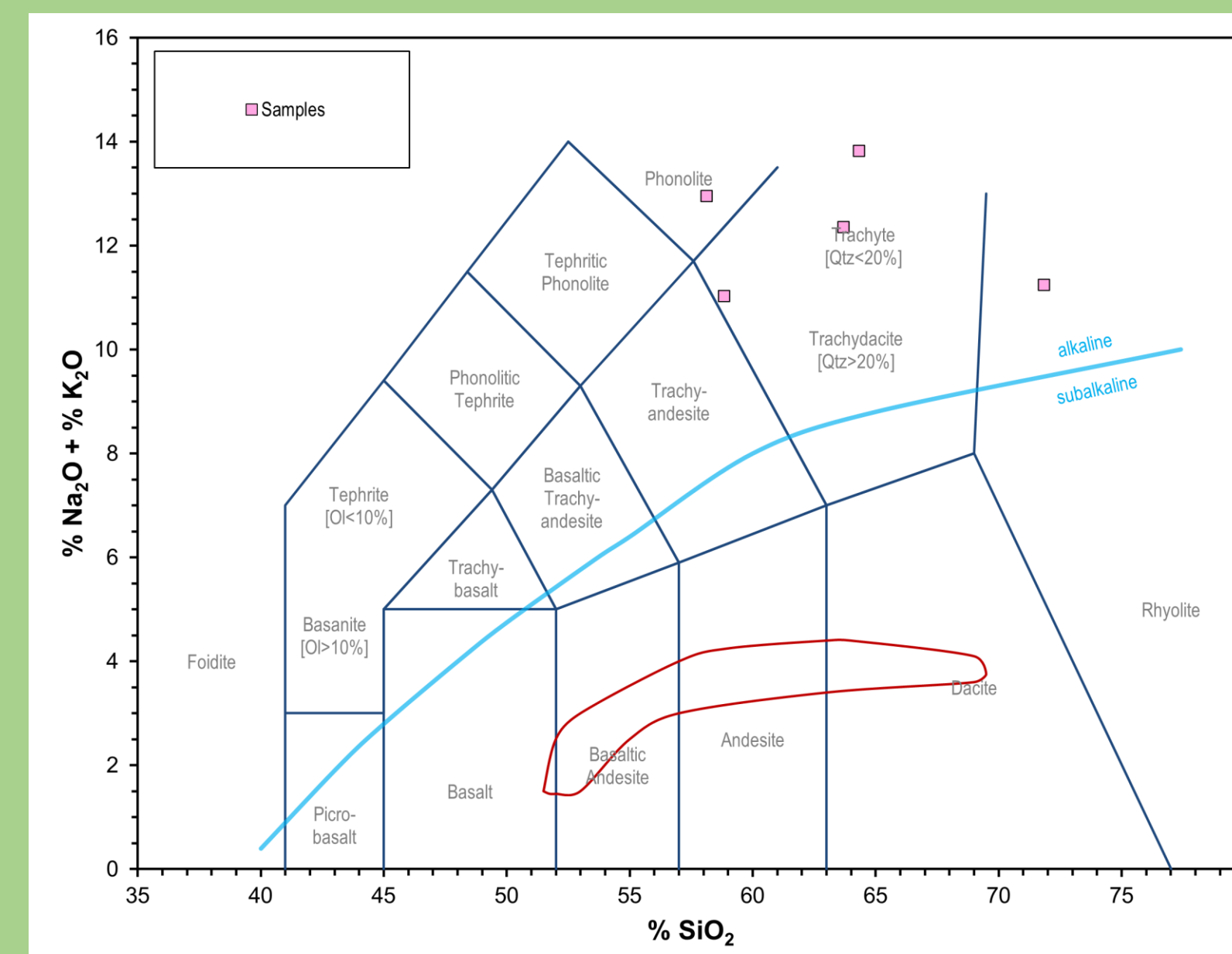


Figure 4 (above): Shows a diagram of the northwestern Black Hills. Specifically showing dikes moving upwards from batholiths into laccoliths. This diagram gives a representation of how igneous intrusions influence topography and elevation.

Total Alkali vs. Silica (TAS) Diagram

Figure 5 (right): Shows a volcanic TAS diagram. Previously mapped records state that the intrusions around the Tinton area are primarily of Trachytic origin, with some amounts of Phonolite (Duke, 2005).



Data Collection & Methodology:

- The initial goal for this project was to catalog any intrusions that had not yet been mapped within the Northern hills.
 - The focus of the research transitioned into looking for unmapped intrusions in the Tinton area.
- The methodology used for going into the field was collecting:
 - Samples large enough to gather hand sample descriptions.
 - Samples small enough for petrographic thin sections.
 - Samples structurally suitable enough for geochemistry analysis.
- Petrographic thin sections are 30 nm-thick slices of rock and the purpose of acquiring them is to:
 - Reveal more accurate mineralogy.
 - Give information as to what is happening within magma chambers at depth.
 - Identify mineral components in our samples.
- Attaining the geochemistry of samples will give us:
 - A clearer classification for each rock.
 - Help us understand what is going on in magma chambers at depth.

Discussion:

- This project is in its early days and will be an ongoing effort into the fall with the return of petrographic thin sections and geochemistry.
- Non-mapped units add extra complexity and information to models of the Tinton area.
 - Units are especially complex if they appear different from what was previously mapped.
- The intrusions we have mapped appear to be a later stage event.
 - less silica-rich magma surrounding the Tinton area.

Conclusion:

- A wide array of information regarding tertiary intrusions within the northern Black Hills exists but a great portion of it is not easily accessible.
- There have been great efforts in understanding the tertiary intrusions for the purpose of gold mining and mineral exploration however, there has been much less focus on using the units to broaden our understanding of large-scale tectonics that brought about the intrusions.
- Gathering and compiling all previously mapped units along with their associated geochemistry into one GIS file will:
 - largely benefit and improve geologist's comprehension of the complexity within the various units.
 - Shed light as to what caused the igneous intrusions.
 - Will be useful for future researchers to work with.

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