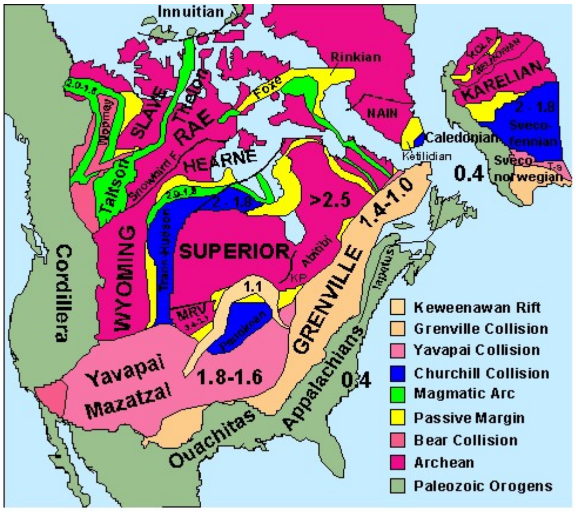
Highland Vallis Ranch
Science Page

The quality and chemistry of the water, soils and forage at Highland Vallis are exceptional. The climate is driven by moisture being lifted and condensing over the mountains which are not going away. Below is a discussion of these and other elements of the science of Highland Vallis. Topics include Migmatites; a Very Long Unconformity; Plate Tectonics, Farallon and Shatsky; Mountains, Minerals, Rifts and Volcanos; Highland Vallis Soils; Highland Vallis Forage; Highland Vallis Water; Highland Vallis Climate and a summary.

Migmatites

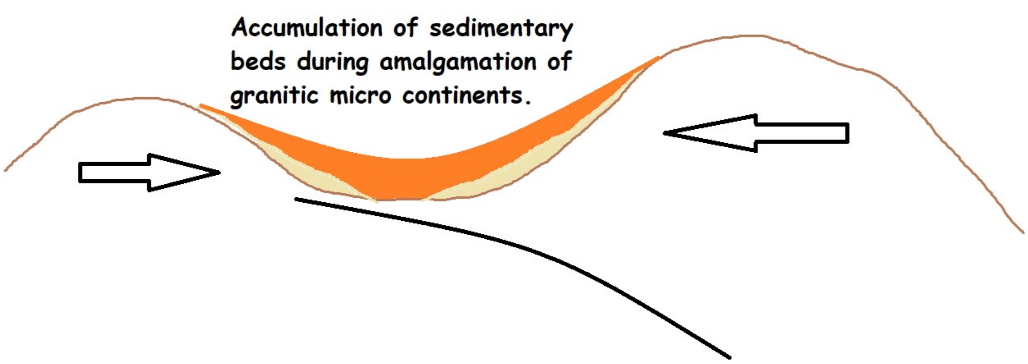
The oldest outcropping rocks on the ranch are called migmatites. They are a transition phase between a metamorphosed sedimentary rock (mostly a metamorphosed mudstone) and an igneous rock (mostly a granite). This rock begins as a shale, then was metamorphosed into slate, schist, gneiss then partially melts into an interbedded igneous granite. The following discussion will shed light on the formation of these oldest rock at Highland Vallis.

Geologic processes do lots of things, one of which is to sort and segregate materials. For example, under windy dry conditions, coarser sand materials are left behind to form sand dunes while the finer materials are blown away to a distant location. The materials are sorted and separated according to their density and aerodynamics. Similarly but different, in Plate Tectonics, more dense basalt racks which make up ocean basin floors tend to be subducted down and under and the less dense granitic rocks tend to float upwards. These lighter, less dense granites then amalgamate, and make up our continents. Our existing North American continent is actually an amalgamation of older, smaller, continents. The following diagram from Wikipedia Wyoming Craton gives a simplified insight as to the geologic complications of the formation of our existing continent. Essentially, each area is its own microcontinent in the formation of the existing North American Plate.



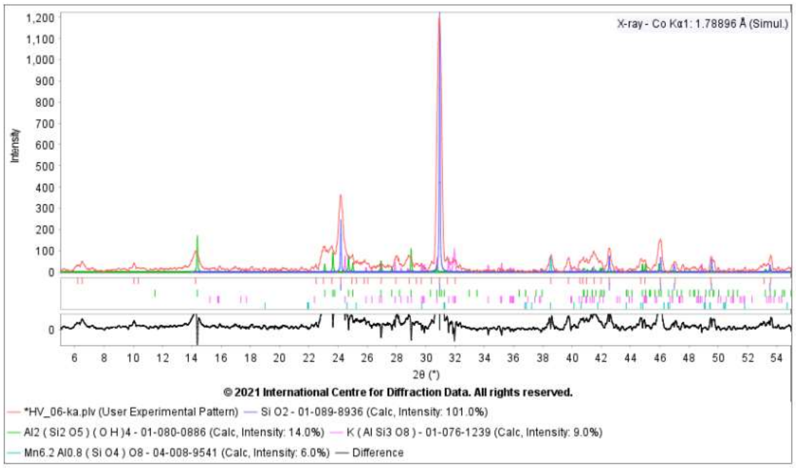
Wyoming Craton - Wikipedia

As these smaller micro continents are drifting together in the formation of the larger continent, basins are forming and materials are being shed from the smaller continents into the basins to form sedimentary rocks – shales for example.



The Highland Vallis story begins about 2 to 2.5 billion years ago which is about half way through the age of the earth. These smaller previously formed granitic microcontinents are drifting together and shedding material into the existing basins. This is the origin of the Highland Vallis migmatite materials and some of the oldest rocks on the continent. The chemistry of these rocks suggest that they were originally a kaolinitic mudstone. Kaolinite typically forms from the breakdown of minerals in a hot humid environment – a tropical environment. The following XRD analysis gives the mineral assemblages of the shaley / schistose end of the migmatite consisting of quartz, kaolinite and microcline – a sandy mudstone with some potassium feldspars.

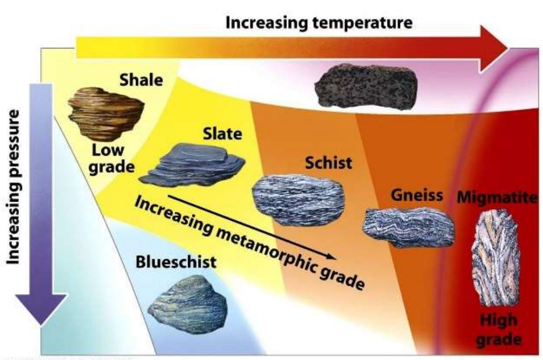
Sample 6- HV06



	Compound Name	Mineral Name	QM	Peaks Matched	I Ratio	I %	I/Ic	Est Wt	PDF #
1	Silicon Oxide		S	7 of 7 *(100%)*	1.01	77.53	2.96	51%	01-089-8936
2	Aluminum Silicate Hydroxide	Kaolinite-1A	I	22 of 72 *(31%)*	0.14	10.72	0.87	24%	01-080-0886
3	Potassium Aluminum Silicate	Microcline	I	15 of 76 *(20%)*	0.09	6.84	0.59	23%	01-076-1239
4	Manganese Aluminum Silicate Oxide		P	6 of 28 *(21%)*	0.06	4.91	4.39	2%	04-008-9541

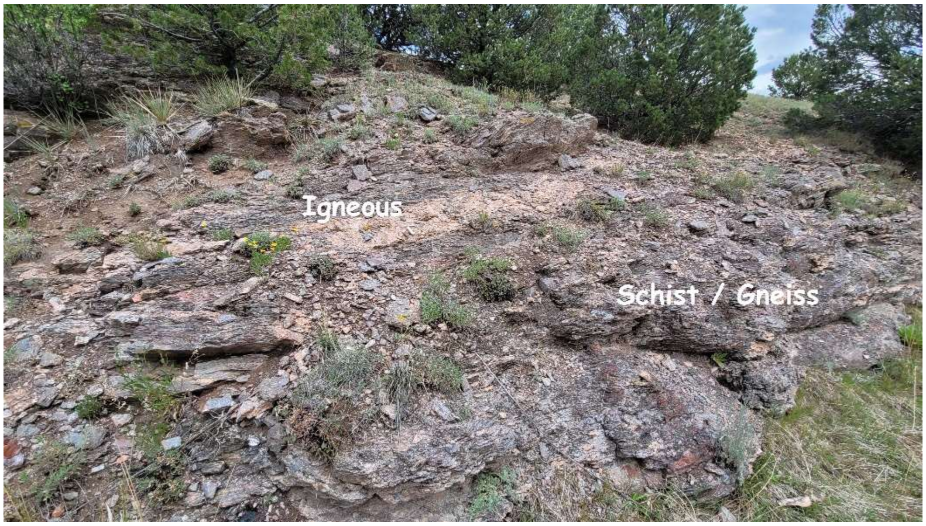
Shaley Schist- Mineral assemblage is predominantly quartz, alkali feldspar and clay. Fine to medium grained, reddish purple, foliated, mica minerals. Schistose rock is a byproduct from a former mudstone (kaolinite).

In the following billion years and more, these original sedimentary rocks, mostly mudstones, are buried and begin the transition from sedimentary rocks through metamorphosed rocks eventually to melted granitic rocks. The following diagram helps to understand this process from shale (mudstone / clays) to migmatite.



Page 250c Earth: Portrait of a Planet 3/e
Original artwork by Gary Hincks

The following image is that of an actual migmatite on Highland Vallis, this is one with a particularly thick (about 1 foot) igneous seam within the schistose (unmelted) material.



To be fractal is to be similar as scale is changed. In other words, what is seen on the small scale is also seen on the large scale and vice versa. There is a "fractal-like" appearance to these older migmatite rock formations. I see an alternating igneous – metamorphic (migmatite) trend in the large-scale outcrops that is similar to the small-scale individual rocks. It is unclear whether these are alternating melts, dikes, faults or something else. This fracture trend is north – south, seen across the ranch and probably contributes to the topographic low of the area. In the following image, a migmatite band is flanked on either side by a granite. Within this granite is a xenolith or inclusion of the migmatite within the granite. This suggests to me that the granite was once the migmatite and that is has completely melted into the granite, that is, all but the xenolith. However, there could be many alternate explanations.

Highland Vallis

Migmatite Xenolith within Granite

It is unclear whether the striped nature of the oldest migmatite rock formations are due to melting, dikes, faulting or something else.

A Very Long Unconformity

Imagine your retired Uncle Albert is going to pull a family album together. He gathers all of the family photos and history from 1850 forward. Uncle Albert likes a cocktail and cigar in the evenings. One evening he drifts off to sleep after spending the day working on the family album, the lit cigar falls out of his hand and onto the stack of old newspapers and catches on fire. Poor Uncle Albert and all of the family information is gone, everything is lost in the fire.

The above image reflects the human vision of a geologic unconformity. It is not that things didn't happen, it's just that we lost the direct record of them. We still know much, we would know the family went through the Civil War, WWI, Roaring 20's, Depression, WWII, Korean Conflict, Vietnam War and on and on. Unfortunately, the photo of great grandad in a WWI uniform is now lost forever.

At Highland Vallis there is an unconformity from approximately 2 billion years ago to approximately 35 million years ago. A lot happened during this time, truly a lot, but those rocks that represent this time period are now missing. There are two things to remember regarding this unconformity: First, things did happen we just don't have a record of them at this particular location; and second, because the rocks are gone, the missing rocks are not having an impact going forward. That is, the missing rocks are not having an impact on such things as current soil development or grass or forest growth. As a result, we will let most of this time go without discussion but it is an important fact to keep in mind.

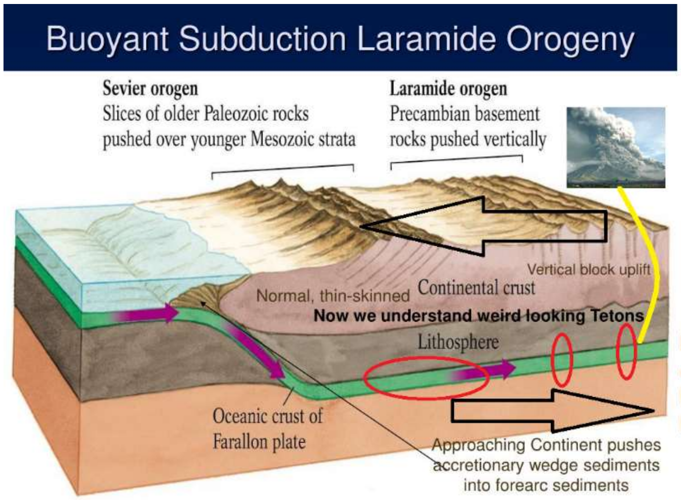
Plate Tectonics, Mountain Building, Farallon and Shatsky

Starting about 160 million years ago, in the previously mentioned unconformity and in a plate tectonic sense, North America began drifting westward, away from Africa and Europe. Simultaneously, located west of North America (in the Pacific) was another plate called the Farallon Plate. This continental plate was drifting eastward. Associated with this plate were probably island arcs (think of Alaska's Aleutian Islands) and possibly an island referred to as the "Conjugate Shatsky Rise." Shatsky was probably an island much like Iceland is today. Iceland is splitting down the middle, one half going east, towards Europe, the other half is moving west. Assuming Shatsky did something similar, the west half is now over close to Japan and east half slid underneath North America.

Also, this Farallon Plate with all of its complications, did not simply dive off into the deeper part of the Earth's mantle immediately as many plates do, but in fact hung in shallower and for a longer distance. What this means is, North America has had a pretty bumpy ride over the Farallon Plate.

The illustrations on the following page are to help you to visualize this event of western North America sliding over this older Farallon Plate. Generally, this process in divided geologically between two orogenies (Mountain building periods) the Sevier and the Laramide.

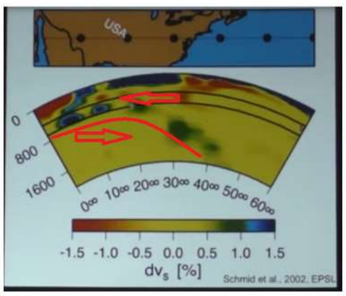
Note the "double subduction" of the Farallon Plate which is supported by actual seismic data.



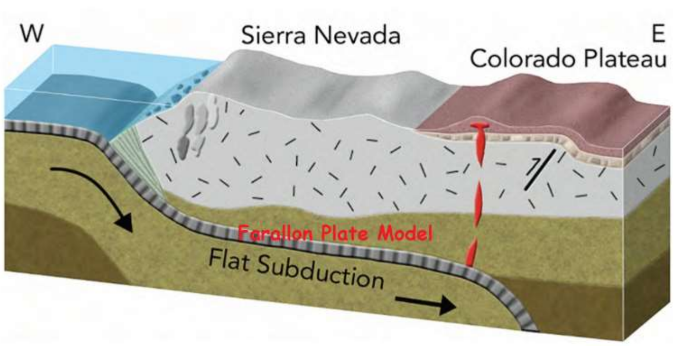
Western North American Volcanics associated with subduction of Farallon Plate and westward drift on NA Plate

North American Plate drifting west away from Europe and sliding over the Farallon Plate.

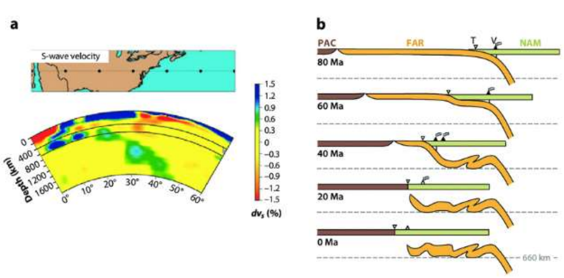
Farallon Plate with Island Arcs and possibly Conjugate Shatsky Rise migrating east under the North American Plate



Seismic data indicating the Farallon Plate flat under Western US then diving down under Eastern US.

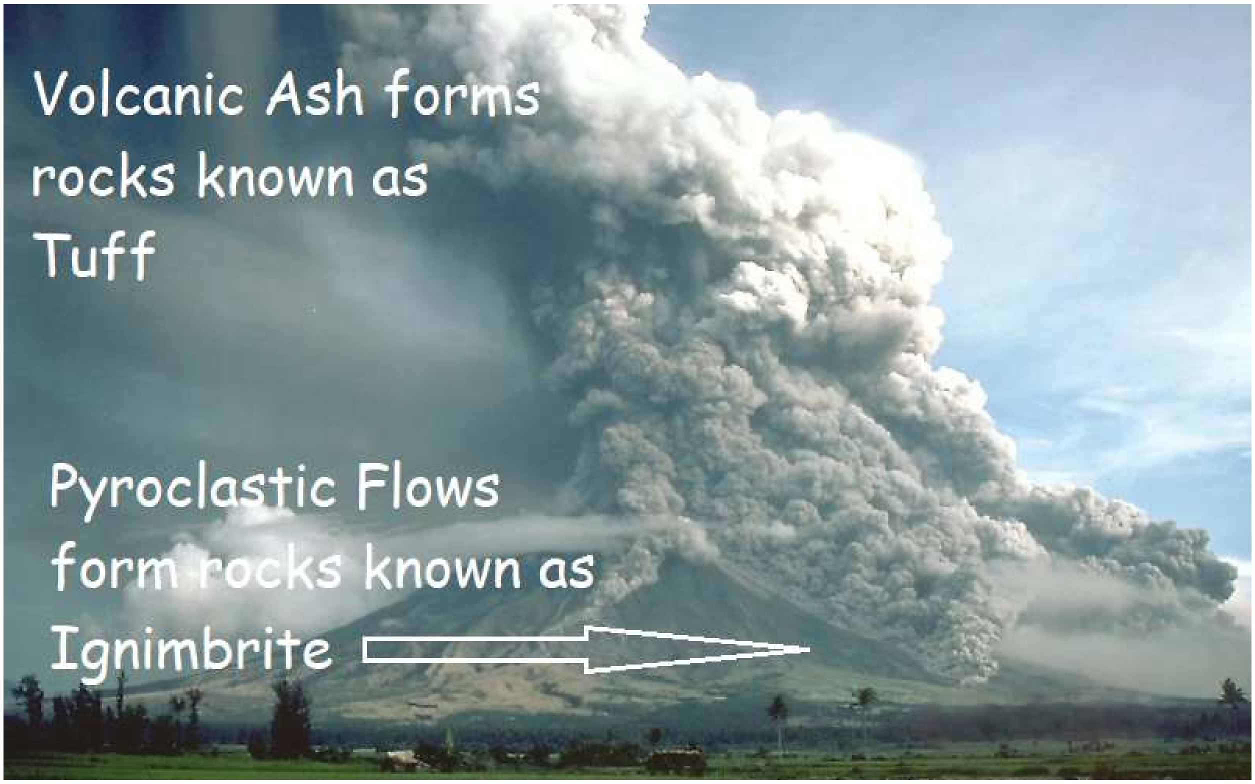


This model corresponds to the actual seismic data indicating a "double subduction" separated by a plateau for the Farallon Plate belwo SW United States / North America.

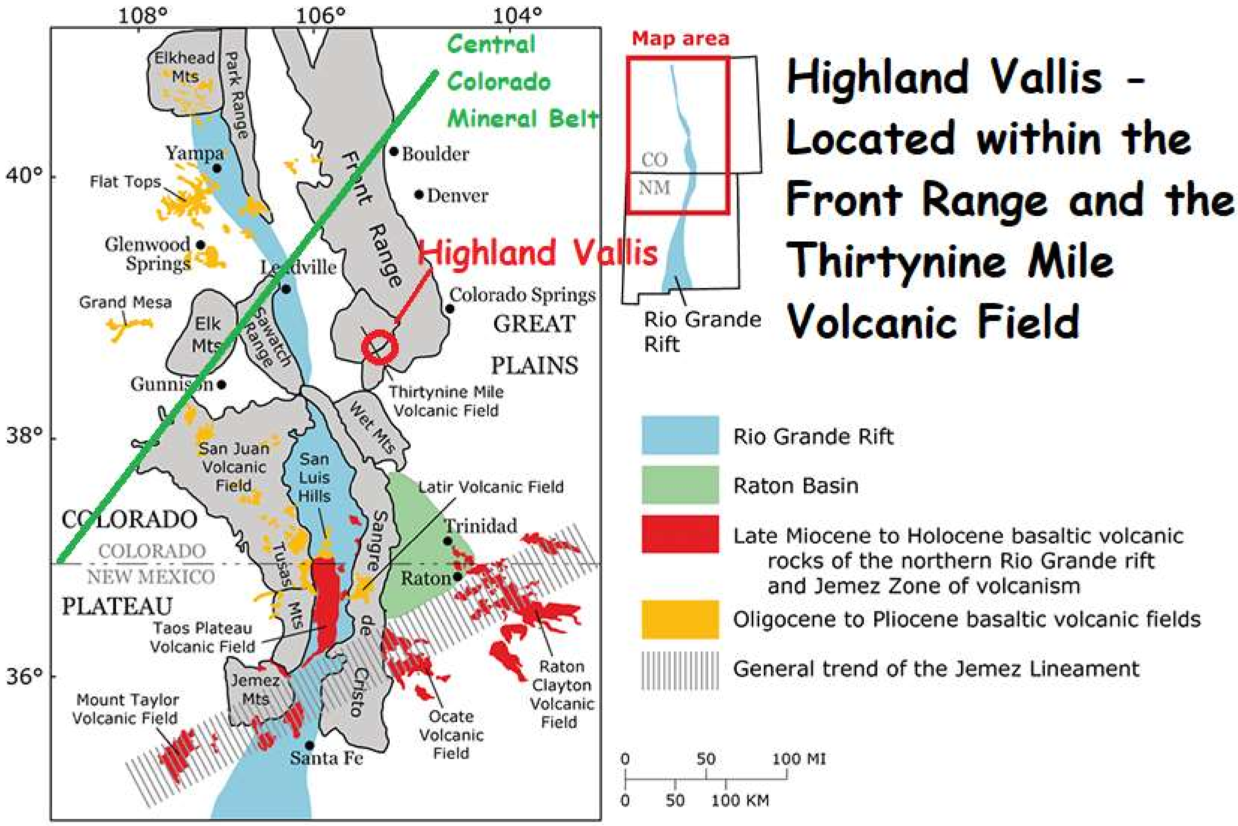


This summary unites seismic information and a Farallon subduction models indicating the roughness of the Farallon Plate under the North American Plate. This roughness of course adds to the complications which we know to be in part - Colorado Geology.

Mountains, Minerals, Rifts and Volcanos



With the background provided in the previous sections about the North American Plate sliding west over the east drifting Farallon Plate with its rough topography, we are now better able to understand the mountains, volcanoes, pyroclastic flows and mineral development of Colorado and Highland Vallis' relationship within this area.



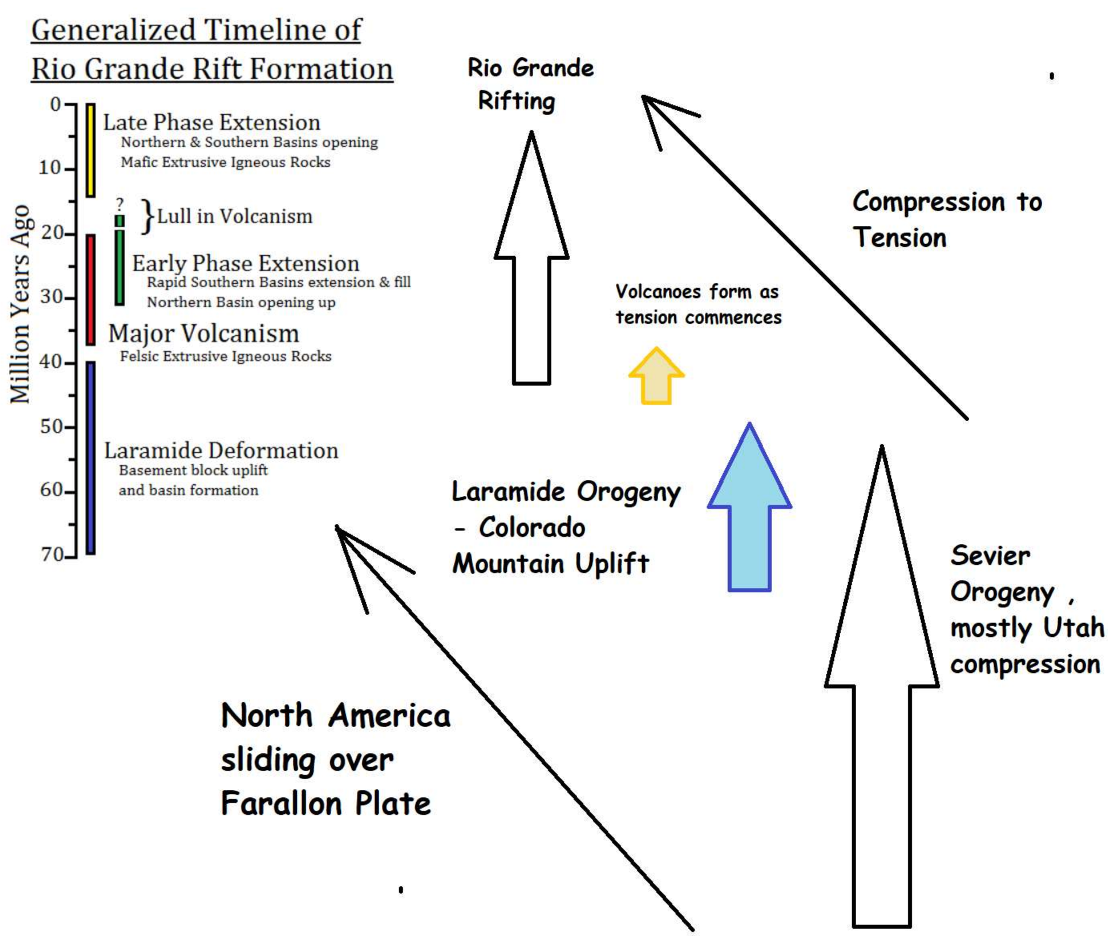
First, think about the mountains, think about an entire continental plate sliding underneath our own plate. There are three episodes, two primary mountain building episodes and a basin forming episode. The Sevier Orogeny and the Laramide Orogeny are compressional events and the Rio Grande Rift is an extensional or tensional event.

The Sevier (pronounced "severe") Orogeny is really the precursor to Colorado mountain building. Think more of this event affecting Utah and the age range of 160 to 50 million years ago. But, to understand the complete history, you should begin by being aware of this beginning orogeny.

Next is the primary Colorado mountain building orogeny – the Laramide. Compared to Sevier, the Laramide is further east (in Colorado) and younger (80 to 30 million years ago). So, the Sevier – Laramide Orogenies together is more of a west to east progression of mountain building as our continent drifted west over the Farallon Plate.

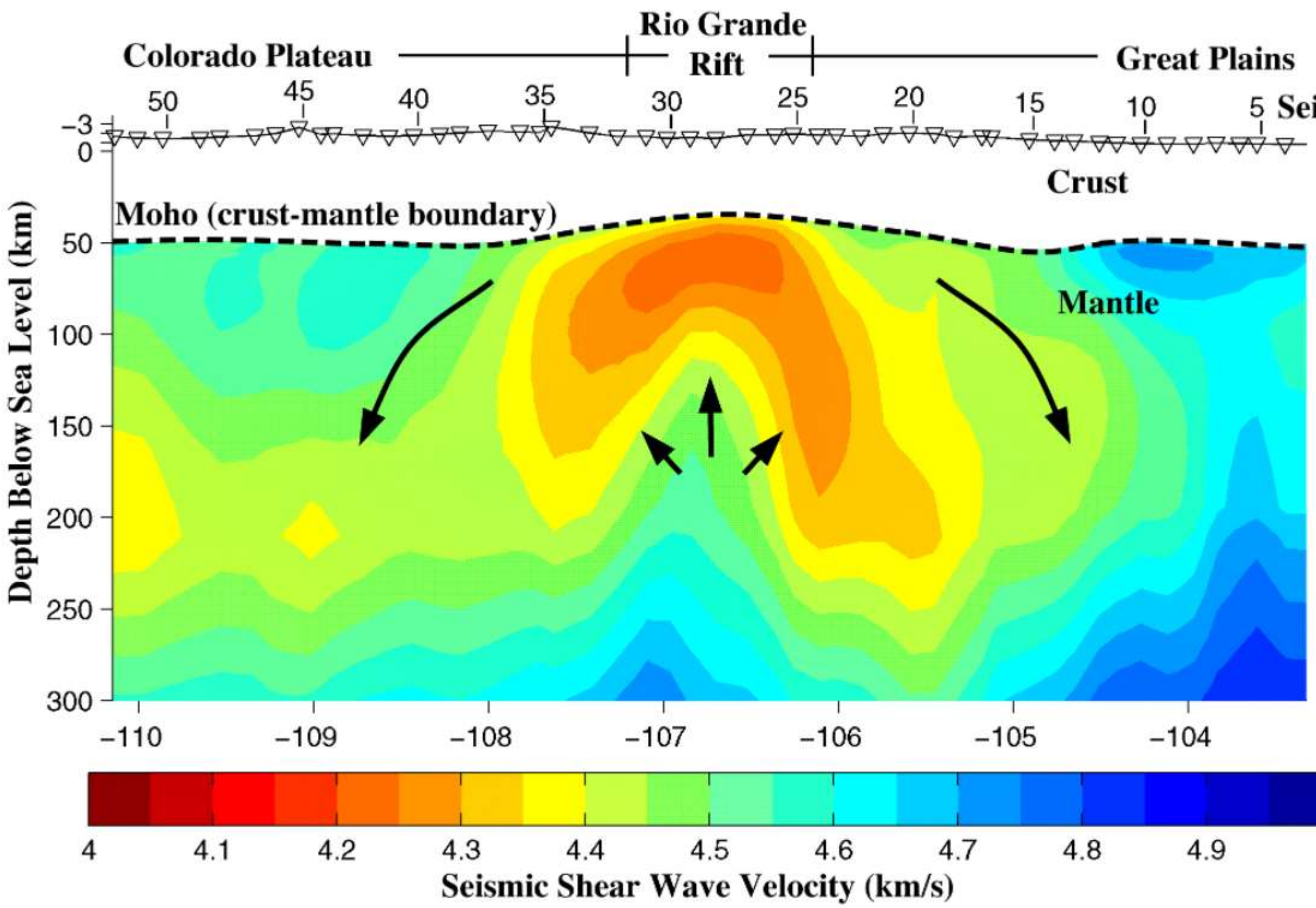
Finally, after this progression of compressional forces, we begin to change to extensional forces and the continent begins to pull apart or stretch. An excellent human scale example of this is a chiropractor's traction machine – it lifts and stretches the back. A similar thing happens within a continental plate: lifting, relaxing and releasing pressure. A decrease in pressure within the continent, and especially a magma chamber under or within a continental plate, can facilitate the formation of gases and bubbles within the magma. This is not unlike a shaken-up Coke bottle with the lid coming off. The result is explosive volcanos with tuffs and ignimbrite rock formations being formed. A tuff formation is the rocks formed from an ash fall of a volcano and an ignimbrite is what is formed from a pyroclastic flow coming down and spreading out from the volcano. See the opening illustration of this section for a visual.

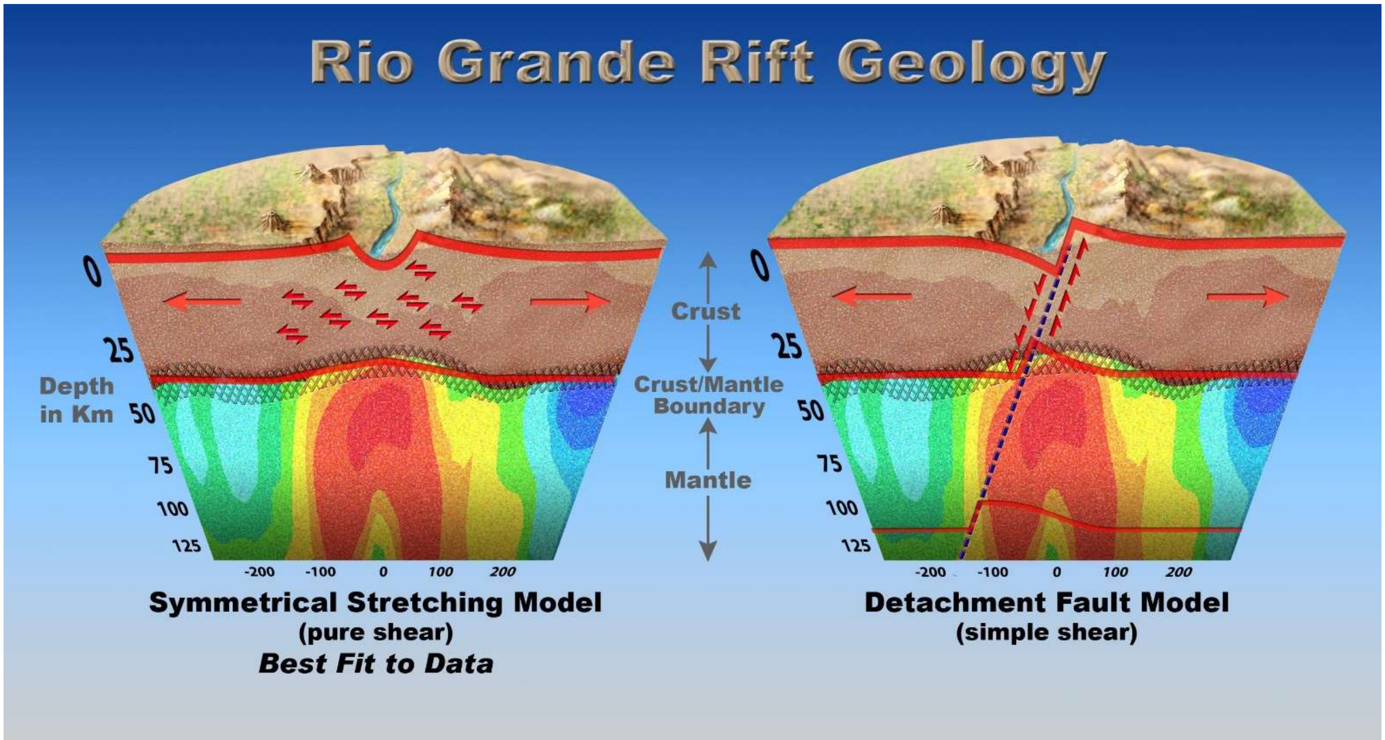
Also associated with the tensional or extensional situation, the earth expands and gravity pulls down forming basins such as the Tularosa Basin with White Sands National Monument in New Mexico or the Alamosa Basin in Colorado and possibly the Yampa Valley of Northern Colorado. Below is an illustration to help with visualization of the timing of these events. The different arrows give an indication of the relationship and lengths in millions of years of the events. Use this illustration by looking from the bottom up.



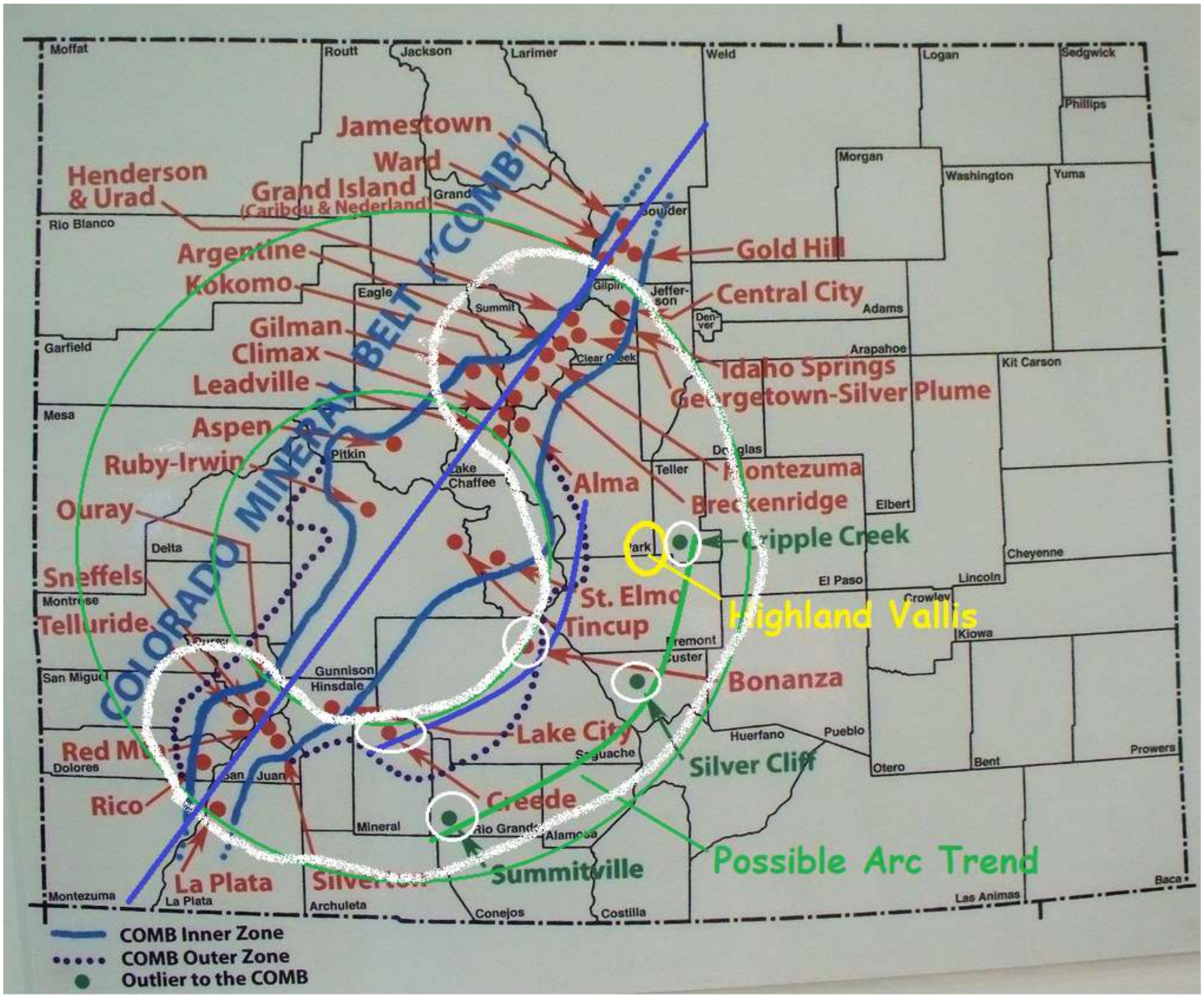
Rifting is the uplift and separation or extension of a continent. It results in tensional forces and basins or topographic lows. This may seem counter intuitive to have an uplift or rise result in apparent lower topography but mathematically a certain amount of land is being spread over a larger area. The basins "fall" into the extra space created. Typically, this forms from a linear heat source from the deeper parts of the earth, the Mantle.

Two very important aspects of rifting are a deep-seated heat source and the distance between the heat source and the surface is less than average. This causes shallow heating, heats and moves fluids, allows for magma formation, the shallowness allows for a decrease in pressure on the magma resulting in gaseous volcanos and the fractures formed with the rifting allow for conduits for fluid and magma movement formingboth volcanos and magmatic dikes.



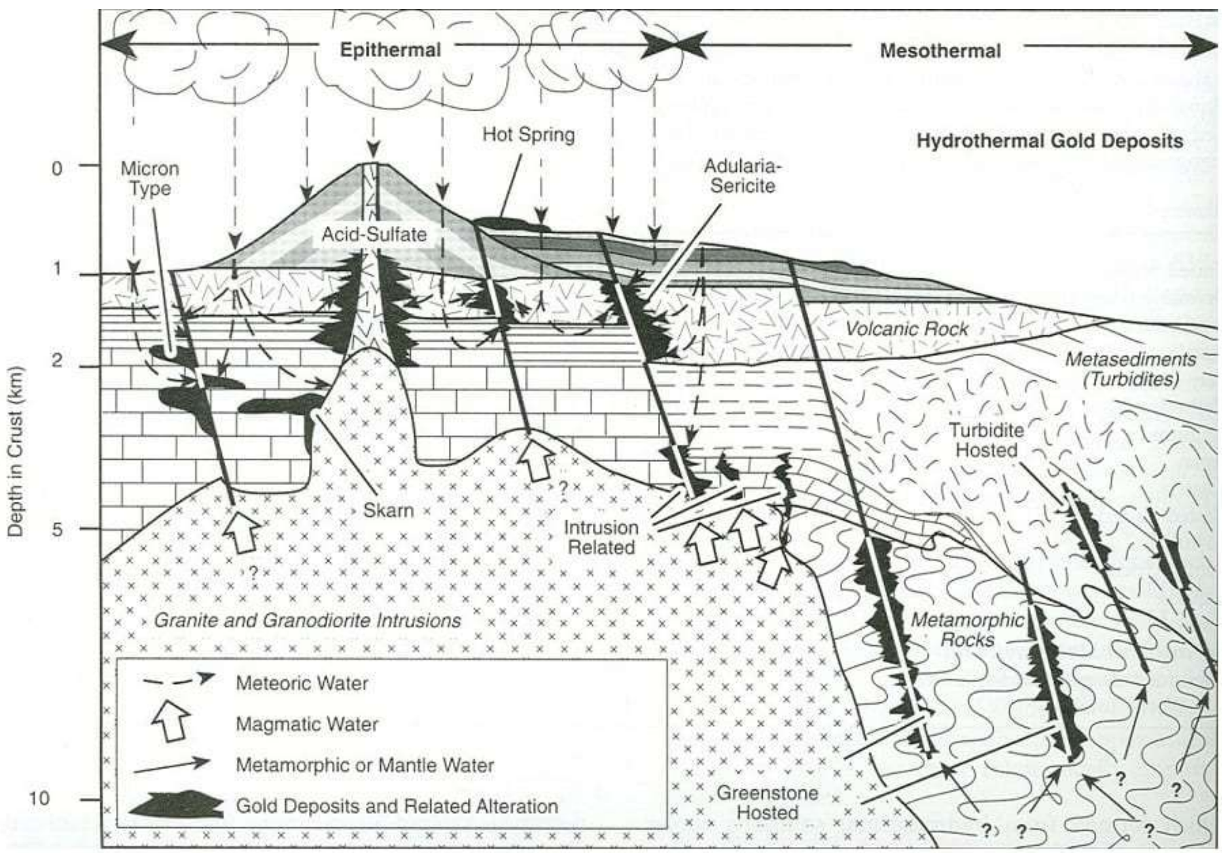


The primary linear Colorado Mineral Belt has produced in the range of 25 million Troy oz of gold among other minerals and likely started in the Pre-Cambrian and maybe associated with the original formation of the basin that produced the migmatites at Highland Vallis. The linear nature of the trend suggests a possible fracture or suture between two micro continents then reactivation may have occurred during the Sevier Orogeny and the Laramide Orogeny. Finally, during activation of the Rio Grande Rifting and volcanics we had magma and fluids moving up and along the fracture zone. This would likely result in the deposition of the minerals.



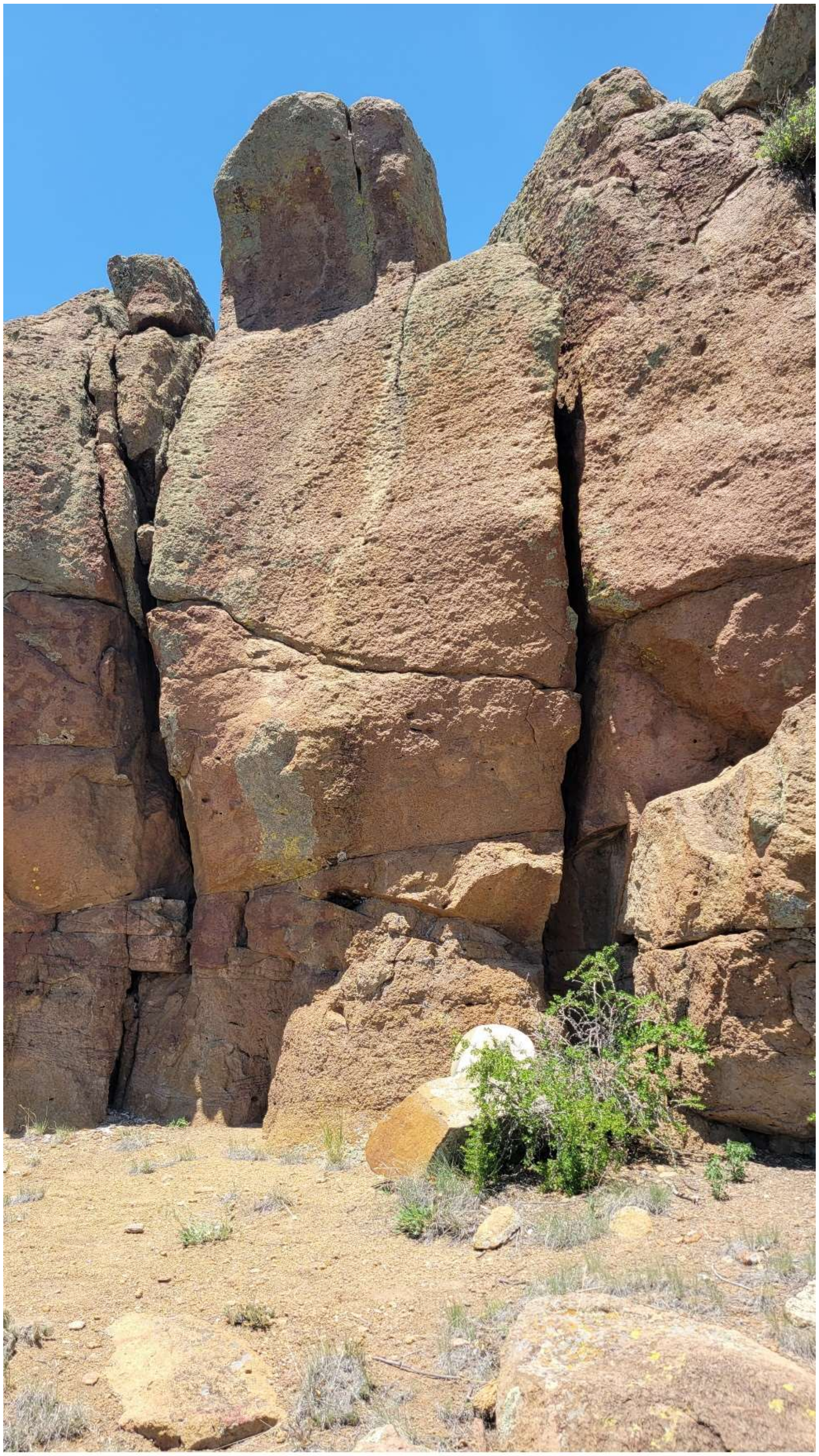
The Colorado Mineral Belt is conventionally described as a NE-SW trend but there are also other deposits in Colorado that could be inferred to promote a secondary trend, an arc trend that ties the ends of the linear belt. The Cripple Creek volcanic related gold deposit is away from the linear trend and on this arc trend. It appears to be fracture related hydrothermal deposition after volcanic.

The diagrams of Cripple Creek indicate a carbonate sedimentary country rock area (meaning sedimentary rocks prior to the volcanics). However most of the regional maps indicate the country rocks are migmates being the same found at Highland Vallis. Perhaps the Cripple Creek country rocks are a different lithofacies of the migmatites found at Highland Vallis. Possibly it is more of a shelf carbonate than the deeper shale kaolinite Notice the metamorphosed turbidites on the flank of the main feature on the following diagram, this would be associated with shale clastics.
So, the gold, besides being in the throat of the Cripple Creek volcano, seems to be hydrothermal (low to medium temperature) and associated with the faults and fractures.



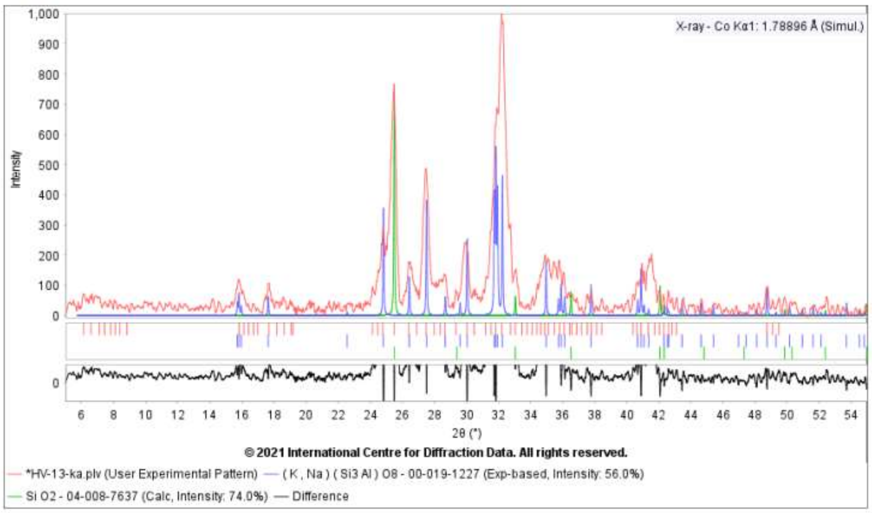
At Highland Vallis there are tuffs and ignimbrite outcrops formed from volcanics scattered across the ranch, they are the uneroded remnants of several layers formed from the volcanos of the area. These are likely interbedded between Cripple Creek associated volcanics and 39 Mile Volcanics which are principally located to the north and west. The 39 Mile volcanics are the same group of volcanics associated with the burial and preservation of trees at Florissant Fossil Beds National Monument located north of Highland Vallis.

The chemistry of the volcanics is variant from intermediate (andesitic) to felsic (rhyolitic) meaning a good combination and mix of elements. The photo below is of a beautiful felsic ignimbrite outcrop with abundant christobolite and sanadine. A nearby and probably associated volcanic outcrop (Rocky Point sample) has a much higher sanadine plus vermiculite is seen which would greatly increase the quality of the soils that derive from these rocks. Although not a lot of vermiculite in this sample it does give a window into the decomposition of these rock formations.



Example Ignimbrite at Highland Vallis
See below for analysis

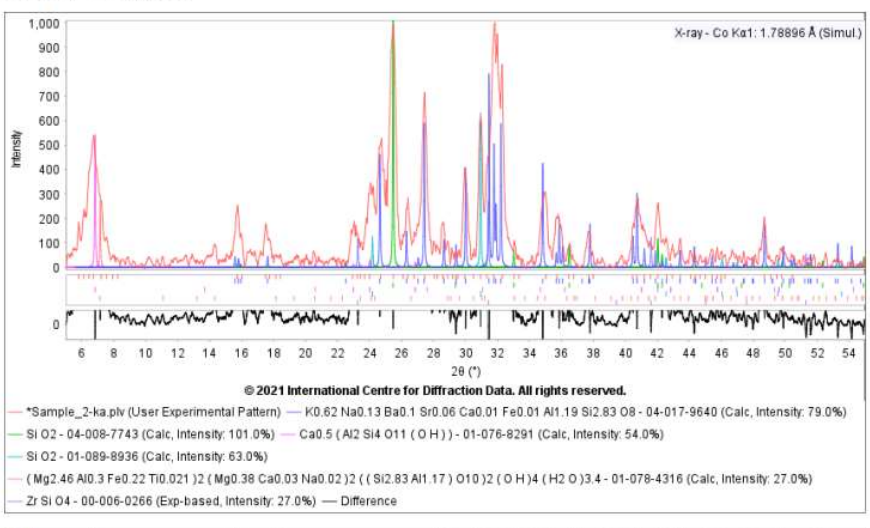
Sample HV-13:



	Compound Name	Mineral Name	QM	Peaks Matched	I Ratio	I %	I/Ic	Est Wt	PDF #
1	Potassium Sodium Aluminum Silicate	Sanidine	S	19 of 35 *(54%)*	0.56	43.10	0.78	83%	00-019-1227
2	Silicon Oxide	Cristobalite	B	6 of 8 *(75%)*	0.74	56.90	5.03	17%	04-008-7637

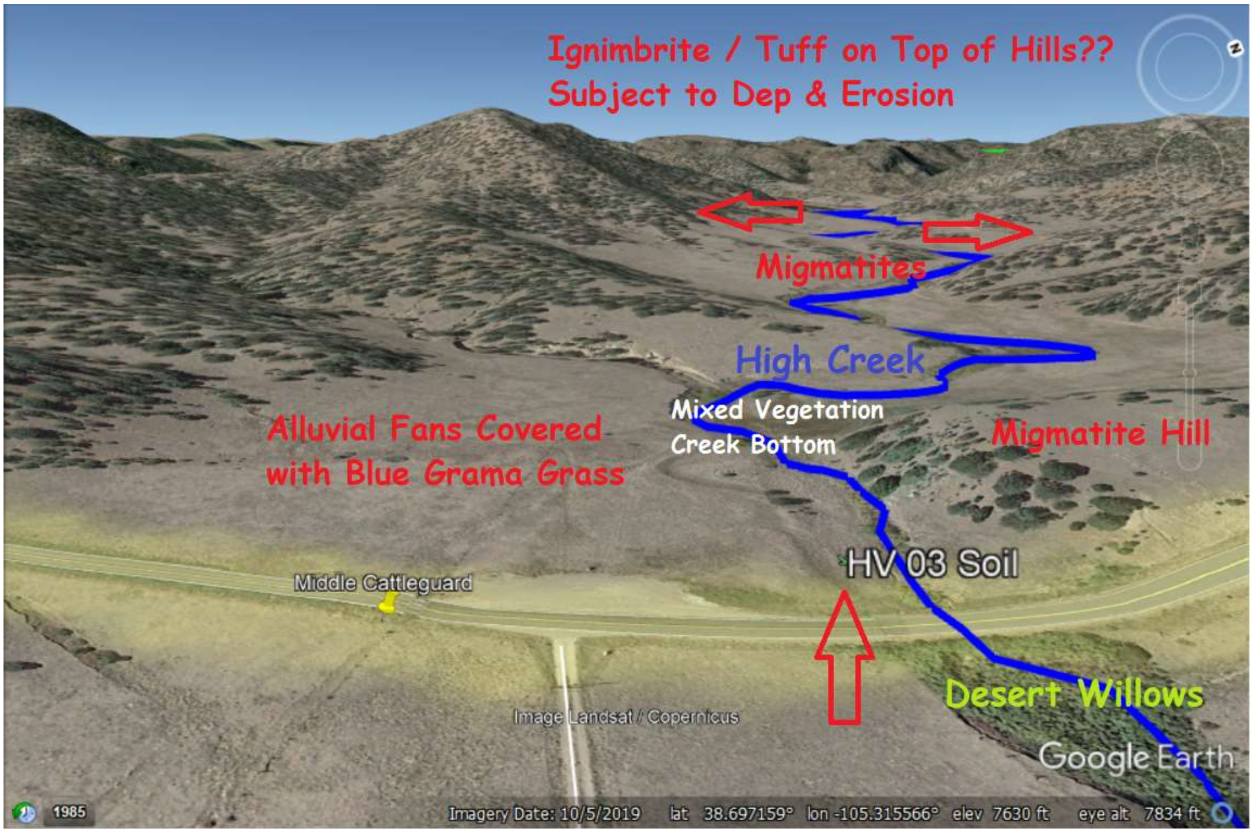
Ignimbrite- Mineral assemblage is predominantly sanidine and quartz. Chemically related to the Rocky Point sample. Cristobalite is very common in ignimbrites and most ignimbrites are silicic with generally over 65% SiO2 which is what is seen in the above graph.

Sample 2 – Rocky Point



	Compound Name	Mineral Name	QM	Peaks Matched	I Ratio	I %	I/Ic	Est Wt	PDF #
1	Potassium Sodium Barium Calcium Strontium Aluminum Iron Silicon Oxide	Sanidine	B	27 of 45 *(60%)*	0.79	22.43	0.75	66%	04-017-9640
2	Silicon Oxide		S	7 of 10 *(70%)*	1.01	28.77	5.03	13%	04-008-7743
3	Calcium Aluminum Silicon Oxide Hydroxide		H	13 of 36 *(36%)*	0.54	15.51	18.62	2%	01-076-8291
4	Silicon Oxide		S	4 of 6 *(67%)*	0.63	17.84	2.96	14%	01-089-8936
5	Sodium Calcium Magnesium Aluminum Iron Titanium Aluminum Silicon Oxide Hydroxide Hydrate	Vermiculite	I	11 of 33 *(33%)*	0.27	7.81	15.1	1%	01-078-4316
6	Zirconium Silicate	Zircon	S	4 of 6 *(67%)*	0.27	7.64	4.89	4%	00-006-0266

Highland Vallis Soils



The previously discussed migmatite and ignimbrite rock formations are eroding to form excellent soil horizons. With a mostly black appearance the Highland Vallis soils appear to be predominantly clay but that is not the case. After doing many soils tests, the general texture of the soils are about 2/3 sand size, 1/5 silt size and 1/8 clay size. Remember "sand" is an unusual word in that it has two meanings, one is a size and the other is the chemistry. To be clear, in this paragraph "sand" refers to the size of the particles not the chemistry of the grains. Because the surrounding "mountains" are being eroded into the soils, the soils are very coarse grained and hence 2/3 sand size. As these materials move downslope the overall grain sizes should continue to reduce. The soils are course because they are near to the source of the material – the migmatites and ignimbrites. Generally, these soils are classified as sandy loams.

Soil chemistry suggest the soils are typically about 1/3 sand in a chemical sense, meaning 1/3 silica dioxide, SiO2. The other 2/3 of the soils are a mix of (1) feldspars (potassium, calcium and some sodium); (2) Micas (muscovite and biotite); and (3) clays (kaolinite, illite and vermiculite).

As the soils are developing it appears the biotite is converting to vermiculite, the best clay, first. The muscovite is likely transforming into illite but there is not a lot of direct evidence of that. The kaolinite which is the most degraded and least effective clay is probably a remnant of the original 2 billion year old sedimentary basin. Perhaps the kaolinite formed from the decomposition of the feldspars in the in the original microcontinents.

Highland Vallis Soil Sample HV03 - Undried
Screened, each sample tested by screen size

26													Catch Screen	
27		Qtz	Albite	Orthoclas	Pyrite	Muscovite	Kaolinite	Vermiculite	Mesh		Microns		Screen #	Screen mesh
28	HV03-A	31	11	16	1	31 (Fe+3)	6	4	5	10	4000	2000	2	10
29	HV03-B	23	(Ca) 34	12	1	20 (Fe+3)	5	5	10	35	2000	500	3	35
30	HV03-C	21	27 (Ca)	22	1	20	5	4	35	60	500	250	4	60
31	HV03-D	34	13	18	2	25 (Fe+3)	8	7	60	120	250	125	5	120
32	HV03-E	30	9	23	2	28	7	0	120	230	125	63	6	230
33	HV03-F	27	22	21	1	25	4	0	230	Pan	Less than 63		Pan	Pan
34														
35														

		Catch Screen									
Microns		Screen #	Screen mesh		Sample Vo	Volume S	Sample W	Wt Sum	Vol %	Wt %	Variance
4000	2000	2	10	HV03-A	325	1880	395	2132	17.29%	18.53%	1.24%
2000	500	3	35	HV03-B	700	1880	862	213	37.23%	40.43%	3.20%
500	250	4	60	HV03-C	425	1880	478	2132	22.61%	22.42%	-0.19%
250	125	5	120	HV03-D	325	1880	281	2132	17.29%	13.18%	-4.11%
125	63	6	230	HV03-E	100	1880	111	2132	5.32%	5.21%	-0.11%
Less than 63		Pan	Pan	HV03-F	5	1880	5	2132	0.27%	0.23%	-0.03%
				Totals	1880		2132		100.00%	100.00%	0.00%

Cation Exchange Capacity (CEC) is a soil's ability to hold natural fertilizers like potassium and nitrogen. Higher CEC has higher fertility. Typically, CEC increases in clay soils and decreases in sandy soils. The unique quality of the Highland Vallis soils is that it has the CEC and fertility of a clay soil but the infiltration and fluid mobility of a sandier soil.

SEND TO:

Magnet Geochemical
P.O. Box 657
Bronte, TX 76933-

GROWER:

BUD JOHNSON

SUBMITTED BY:

DATE: 06/10/21

SOIL ANALYSIS REPORT

PAGE: 1

SAMPLE ID	LAB NUMBER	ORGANIC MATTER % RATE ENR lbs/A	PHOSPHORUS P1 (Weak Bray) ppm-P RATE	PHOSPHORUS P2 (Strong Bray) ppm-P RATE	POTASSIUM K ** ppm-K RATE	MAGNESIUM Mg *** ppm-Mg RATE	CALCIUM Ca *** ppm-Ca RATE	SODIUM Na *** ppm-Na RATE	pH SOIL pH	pH BUFFER INDEX	Cation Exchange C.E.C. meq/100g	COMPUTED PERCENT BASE SATURATION K	Mg	Ca	H	Na
HV-01	13961	5.4VH137	13L	57H	421VH	240M	4234VH	37VL	7.5		24.3	4.4	8.1	86.8	0.0	0.7
HV-02	13962	3.5H 100	16L	72VH	212M	475VH	5145VH	155L	7.2		30.8	1.8	12.7	83.4	0.0	2.2
HV-03	13963	1.6L 62	20M	84VH	164L	363H	5615VH	109L	7.7		31.9	1.3	9.3	87.8	0.0	1.5
HV-04	13964	5.8VH146	15L	23L	155L	395H	5333VH	103L	7.9		30.7	1.3	10.6	86.7	0.0	1.5
HV-05	13965	3.6H 103	10L	18L	101VL	266M	4862VH	74L	7.8		27.0	1.0	8.1	89.8	0.0	1.2
HV-06	13966	2.8M 85	14L	30M	348VH	208VH	1692H	32L	6.7		11.7	7.6	14.6	72.1	4.5	1.2
HV-07	13967	5.4VH138	12L	81VH	233H	358VH	4221VH	69L	7.2		24.9	2.4	11.8	84.6	0.0	1.2

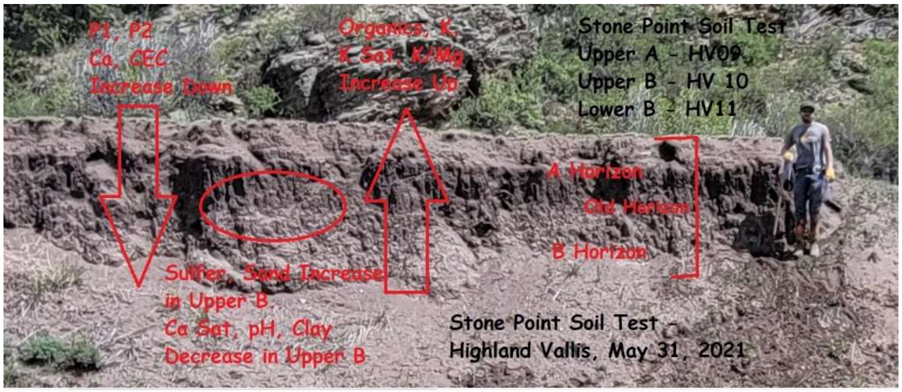
Typical CEC for soil textures
Smart-Fertilizer.com

Soil Texture	CEC
Sand	1-5
Loamy Sand to Sandy Loam	5-10
Loam	5-15
Clay Loam	15-30
Clay	>30

Highland Vallis Texture - Loamy Sand to Sandy Loam

Highland Vallis CEC Ranges from 10 to 35 +/-
Many CEC in the 30 range

With increasing mobility of fluids in the soils there is also increasing mobility of the ions. The following image indicates some changes in soil chemistry in a vertical section.



Upper A - Most Organics and K located at Top

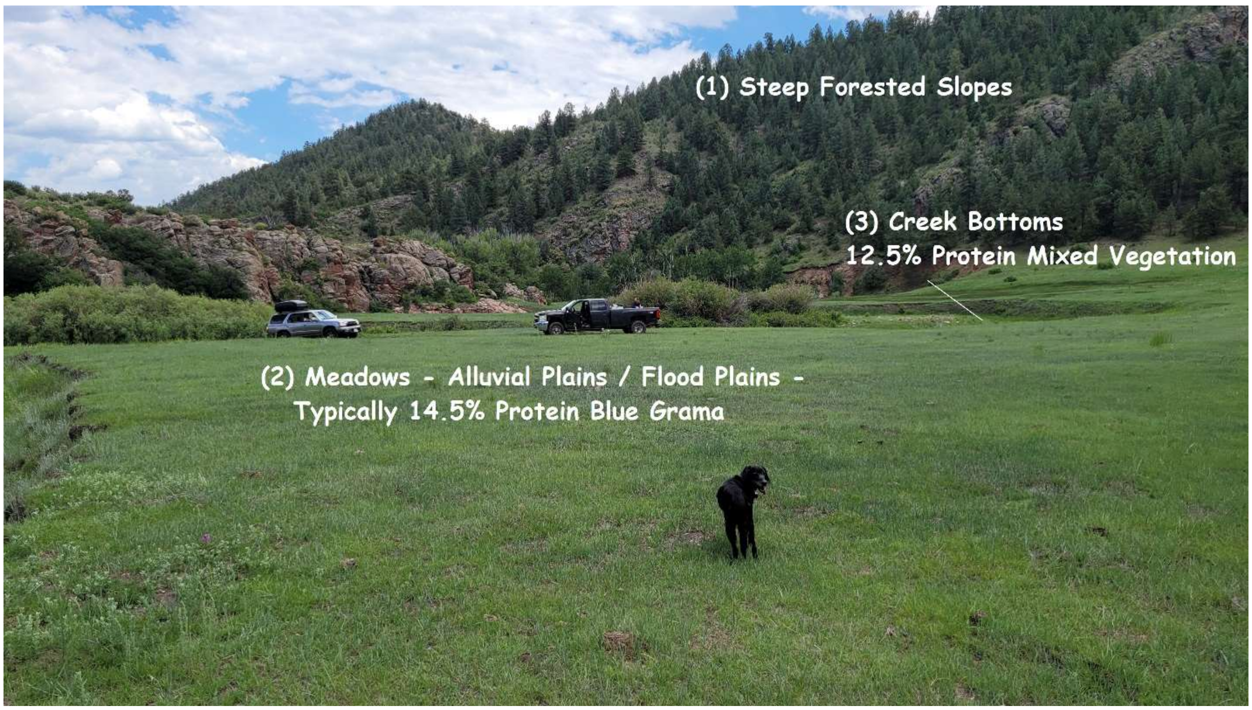
Upper B - Most Manganese, Nitrates, Na, Na Sat,Mg, Mg Sat, Sulfer in middle zone. Least Boron, Ca Sat, clay and lowest pH in middle zone

Most Phosphorous, Calcium, Boron and highest CEC located at bottom.

In summary the soils tend to have the good chemistry of a mixed clay but with the infiltration rate of a sandy loam. This means the ranch is a precipitation sponge, minimizing erosional runoff with good soil chemistry.

Highland Vallis Forage

There are three different areas of forages (1) Steep forested slopes. These have good grass but have not yet been tested; (2) alluvial intermediate slopes – meadows; and (3) creek bottoms.



Due to the slightly increased water availability, the creek bottoms have more vegetation volume with a slightly lower protein content while the meadows have slightly lower vegetation content but a higher protein content.

SEND TO:

Magnet Geochemical
P.O. Box 657
Bronte, TX 76933-

GROWER:

BUD JOHNSON

SUBMITTED BY:

FEED ANALYSIS REPORT

DATE: 07/20/21

PAGE: 1

LAB NUMBER	SAMPLE IDENTIFICATION	MOISTURE %	CRUDE PROTEIN %	DIGESTIBLE PROTEIN %	ADF INSOLUBLE PROTEIN %	CRUDE FAT %	CRUDE FIBER %	ACID DETERGENT FIBER %	ASH %	TOTAL DIGESTIBLE NUTRIENTS %	NITRATE (N03) %	NDF %
20260	HV21 Blue Grama	0.00 62.00	14.50 5.51	9.39 3.57		1.70 0.65		30.76 11.69	9.40 3.57	68.09 25.87		
20261	HV22 Creek Btm Mix	0.00 72.50	12.44 3.42	7.56 2.08		2.45 0.67		29.47 8.10	13.80 3.80	69.53 19.12		

Top line results: Dry wt. basis - Bottom line results: As is basis

LAB NUMBER	NITROGEN %	SULFUR %	PHOSPHORUS %	POTASSIUM %	MAGNESIUM %	CALCIUM %	SODIUM %	IRON ppm	ALUMINUM ppm	MANGANESE ppm	COPPER ppm	ZINC ppm	RFV
20260	2.32 0.88	1.06 0.40	0.22 0.08	1.40 0.53	0.12 0.05	0.43 0.17	0.02 0.01	223 85		65 25	10 4	23 9	
20261	1.99 0.55	3.19 0.88	0.21 0.06	2.34 0.64	0.24 0.07	0.90 0.25	0.09 0.02	373 103		66 18	9 2	23 6	

LAB NUMBER	NE (lactation) Mcal/lb	NE (gain) Mcal/lb	NE (maintenance) Mcal/lb					
20260	0.70 0.27	0.43 0.16	0.68 0.26					
20261	0.72	0.45	0.70					

This report applies only to the sample(s) tested. Samples are

A & L PLAINS AGRICULTURAL LABORATORIES, INC.

By: [illegible] Agronomist

Highland Vallis Samples HV21 & HV22

Grass

HV21 - Blue Grama - 14.5% Protein higher, less forage, less dense and shorter

Sulfur 1.06 Lower
K - 1.4 Lower
Mg - .12 half
Ca - .43 half
Na - .02 Much less (probably better)
Fe - 223 Lower (probably better)

HV21 - Soils

Higher Organic Matter, P1, P2, K, Zn, B
Lower - Mg, Ca, Na, Nitrate, Mn, Fe, Cu

Equal in Sulfur

HV22 (Grass) - Legumes and mixed wet soil grasses - 12.44% Protein, Lower but more forage, thicker and taller

It is much wetter in the creek bottom, higher in sulfur and potassium, about the same in phosphorous and a little lower in nitrogen.

I do not have textures on these two soils but generally the ranch soil textures are 2/3 Sand, 1/5 Silt, 1/8 Clay. The shake out before sending to Houston both indicated a bimodal distribution with HV22 a bit more coarse.

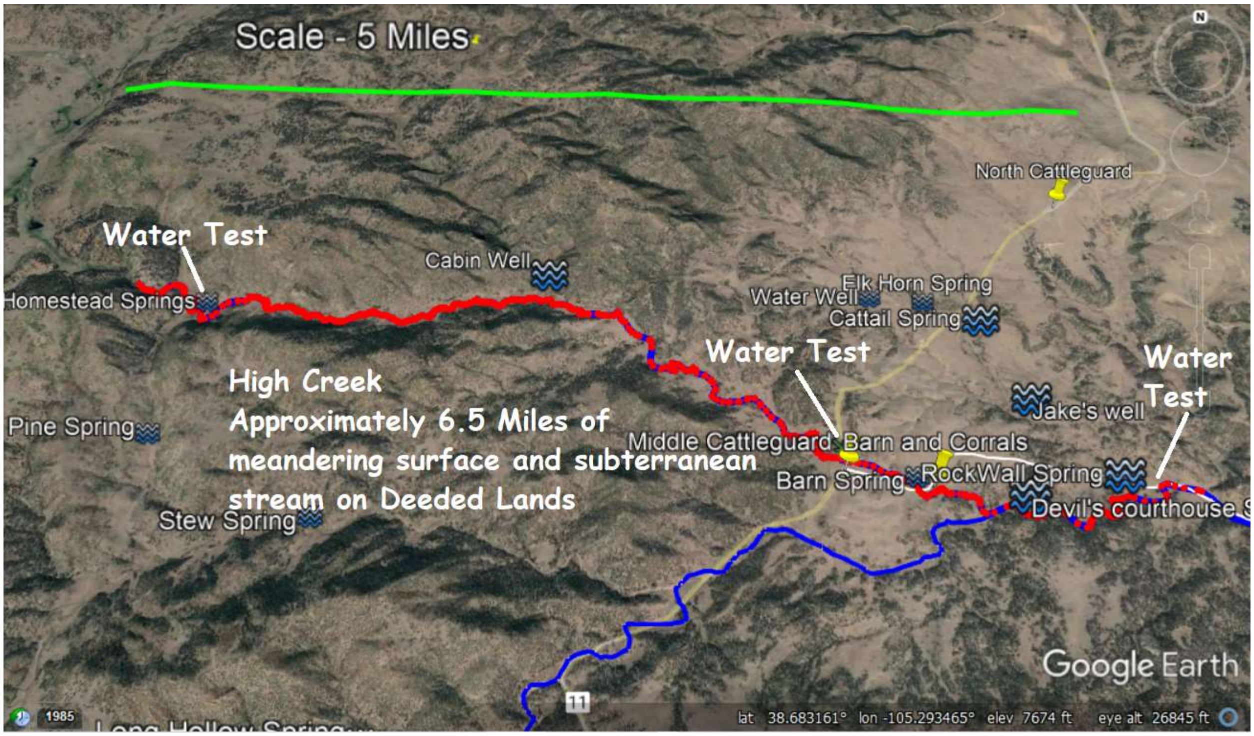
Generally these two soils are low in Zn, Nitrates, sulfur, Mn and Na

Generally these two soils are high in P, K, Mg, Ca,

Generally they are moderate in Fe, Cu and Boron

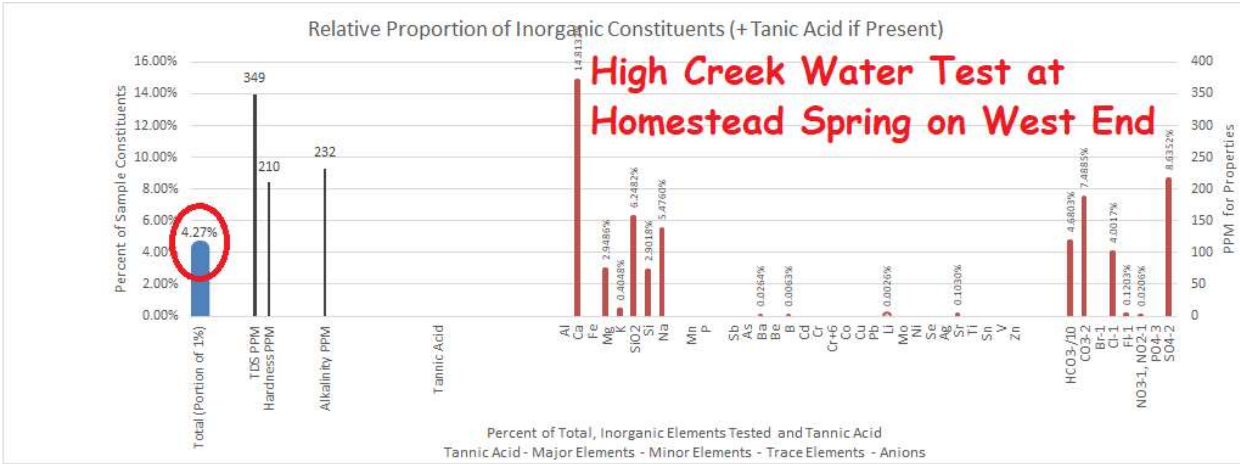
Blue Grama Meadows at Highland Vallis

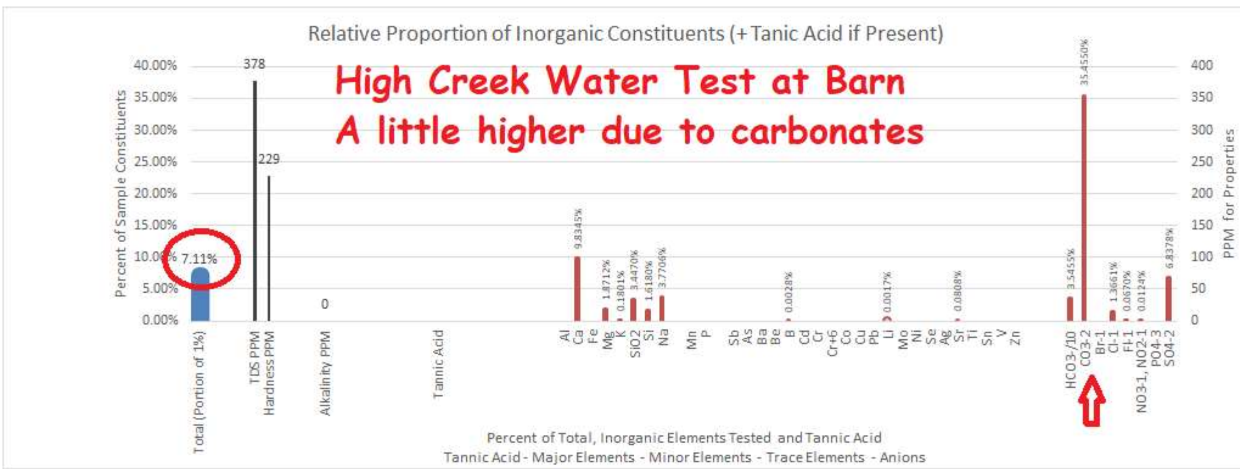
Highland Vallis Water

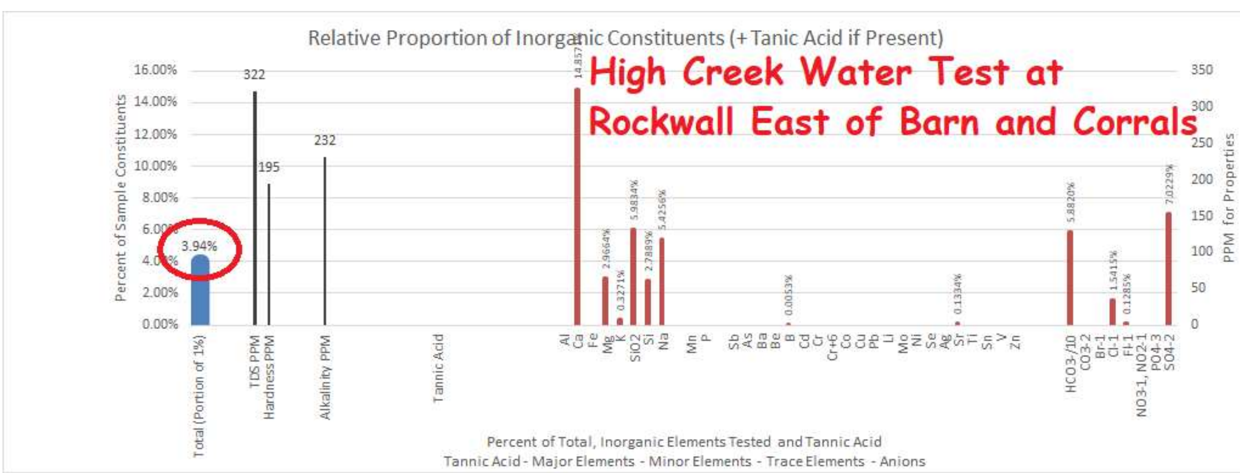


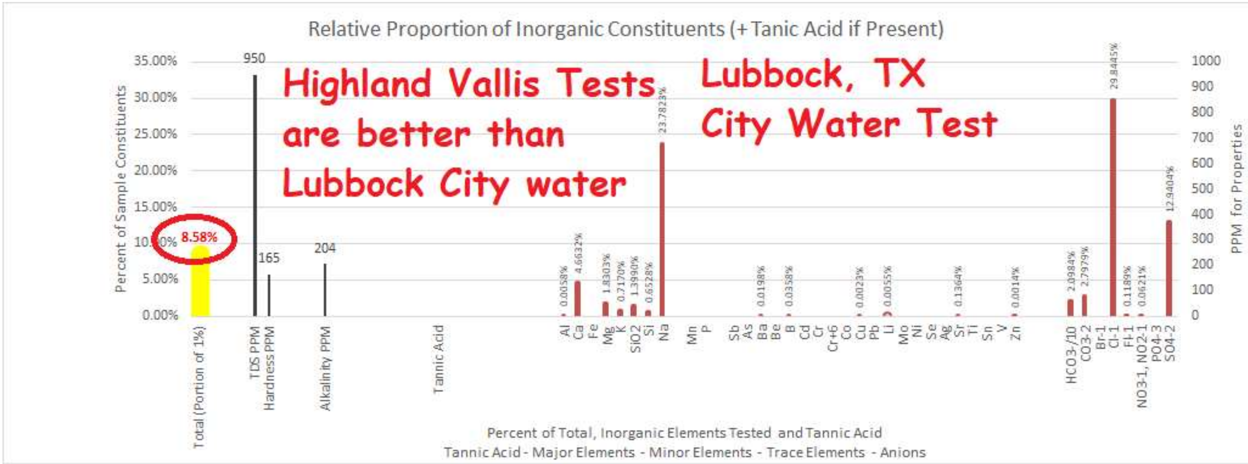
Water Quantity - The primary water source on the ranch is High Creek, a subterranean and surface flow stream which provides ample water for the ranch and more. As previously discussed under soils, the soils materials at Highland Vallis are coarse materials close to the bedrock source material. This "sandy" material allows for most water to migrate underground. Also, an important part of the water flow physics is the stream gradient. As water moves above the ground surface there is no impediment or resistance to stream flow therefore the water can run off faster with the higher mountain gradient. This idea is further magnified by a plant called the Desert Willow. The root system of this plant further slows the downstream movement of the water. You can think of it something like an underground beaver dam. More on this below.

Water Quality – Water quality is excellent the following three water tests are from High Creek, west, east-central and east samples. All three of these samples are better quality water than Lubbock, Texas City Water by comparison.

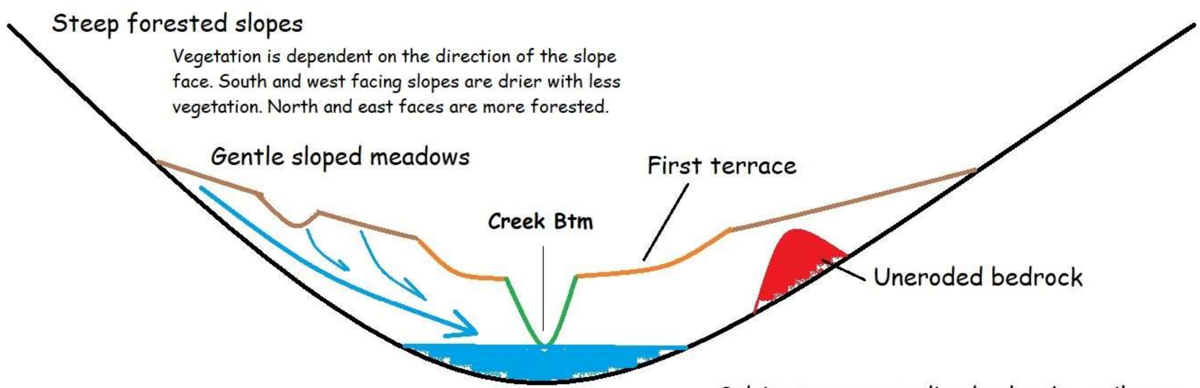

Relative Proportion of Inorganic Constituents (+Tanic Acid if Present)
High Creek Water Test at
Homestead Spring on West End
Percent of Sample Constituents
PPM for Properties
4.27%
349
210
232
2.9486%
0.4048%
6.2482%
2.9018%
5.4760%
0.0264%
0.0063%
0.0026%
0.1030%
4.6803%
7.4885%
4.0017%
0.1203%
0.0206%
8.6352%
Total (Portion of 1%)
TDS PPM
Hardness PPM
Alkalinity PPM
Tannic Acid
Percent of Total, Inorganic Elements Tested and Tannic Acid
Tannic Acid - Major Elements - Minor Elements - Trace Elements - Anions


Relative Proportion of Inorganic Constituents (+Tanic Acid if Present)
High Creek Water Test at Barn
A little higher due to carbonates
Percent of Sample Constituents
PPM for Properties
7.11%
378
229
0
9.8345%
1.8712%
0.1801%
3.4470%
1.6180%
3.7706%
0.0028%
0.0017%
0.0808%
3.5455%
35.4550%
1.3661%
0.0670%
0.0124%
6.8378%
Total (Portion of 1%)
TDS PPM
Hardness PPM
Alkalinity PPM
Tannic Acid
Percent of Total, Inorganic Elements Tested and Tannic Acid
Tannic Acid - Major Elements - Minor Elements - Trace Elements - Anions


Relative Proportion of Inorganic Constituents (+Tanic Acid if Present)
High Creek Water Test at
Rockwall East of Barn and Corrals
Percent of Sample Constituents
PPM for Properties
3.94%
322
195
232
2.9664%
0.3271%
5.9834%
2.7889%
5.4256%
0.0053%
0.1334%
5.8820%
1.5415%
0.1285%
7.0229%
Total (Portion of 1%)
TDS PPM
Hardness PPM
Alkalinity PPM
Tannic Acid
Percent of Total, Inorganic Elements Tested and Tannic Acid
Tannic Acid - Major Elements - Minor Elements - Trace Elements - Anions


Relative Proportion of Inorganic Constituents (+ Tanic Acid if Present)
Highland Vallis Tests are better than Lubbock City water
Lubbock, TX City Water Test
Percent of Sample Constituents
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
8.58%
950
165
204
23.7823%
29.8445%
12.9404%
4.6632%
0.0058%
1.8303%
0.7170%
1.3990%
0.6528%
0.0198%
0.0358%
0.0023%
0.0055%
0.1364%
0.0014%
2.0984%
2.7979%
0.1189%
0.0621%
1000
900
800
700
600
500
400
300
200
100
0
PPM for Properties
Total (Portion of 1%)
TDS PPM
Hardness PPM
Alkalinity PPM
Tannic Acid
Al
Ca
Fe
Mg
K
SiO2
Si
Na
Mn
P
Sb
As
Ba
Be
B
Cd
Cr
Cr+6
Co
Cu
Pb
Li
Mo
Ni
Se
Ag
Sr
Ti
Sn
V
Zn
HCO3-/10
CO3-2
Br-1
Cl-1
Fl-1
NO3-1, NO2-1
PO4-3
SO4-2
Percent of Total, Inorganic Elements Tested and Tannic Acid
Tannic Acid - Major Elements - Minor Elements - Trace Elements - Anions

High Creek Stream Model



Due to the sandy soils and high infiltration rates almost all water is subterranean surface flow and with this there is a tendency for leaching. Sulfur, Zinc and Manganese tend to be low in the soils but acceptable in the water, This suggests leaching.

Subject to protruding bedrocks, soils are deep, sandy loam or loamy sand with good drainage and the limited clays (12% to 16%) are good, vermiculite types of clays.

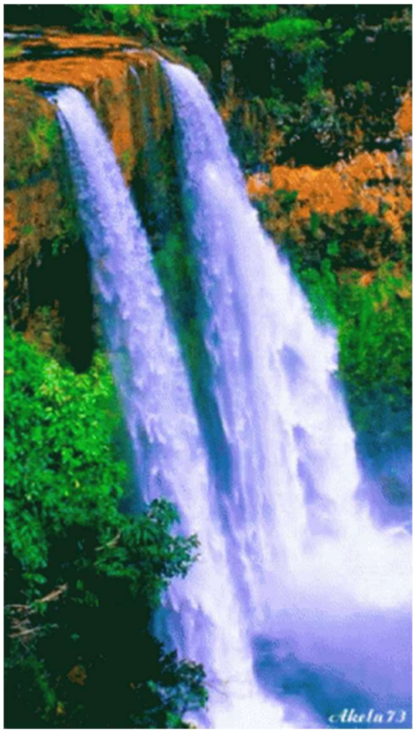
Desert Willows and Stream Flow

In stream beds with consistent water, Desert Willows which are sometimes called Coyote Willows, are common. They are considered an indicator for a healthy environmrnt but they do use a fair amount of water and over the past 70 years there have been attempts to control them to conserve water. Apparently early on there was an issue sometime around the 1950's drought in which a chemical treatment appeared to have the opposite affect and decrease the amount of available water.

Since that time there has been a discrepancy in considering the willows. Landowners tend to believe in control while conservationists do not lend themselves to control.

Following we will consider these options:

If you consider a stream segment, the amount of water exiting that segment is equal to the amount of water entering it plus any additions from springs, tributaries or other sources, less the amount being dissipated by transpiration, evaporation or other means such as irrigation. In other words, if you have 1000 gallons per minute coming in on the upside then you will have 1000 gallons per minute exiting on the low side unless there are additions or subtractions within that segment. In the case of the willows, the addition of willows uses water through transpiration and decreases the amount of water to exit the stream.

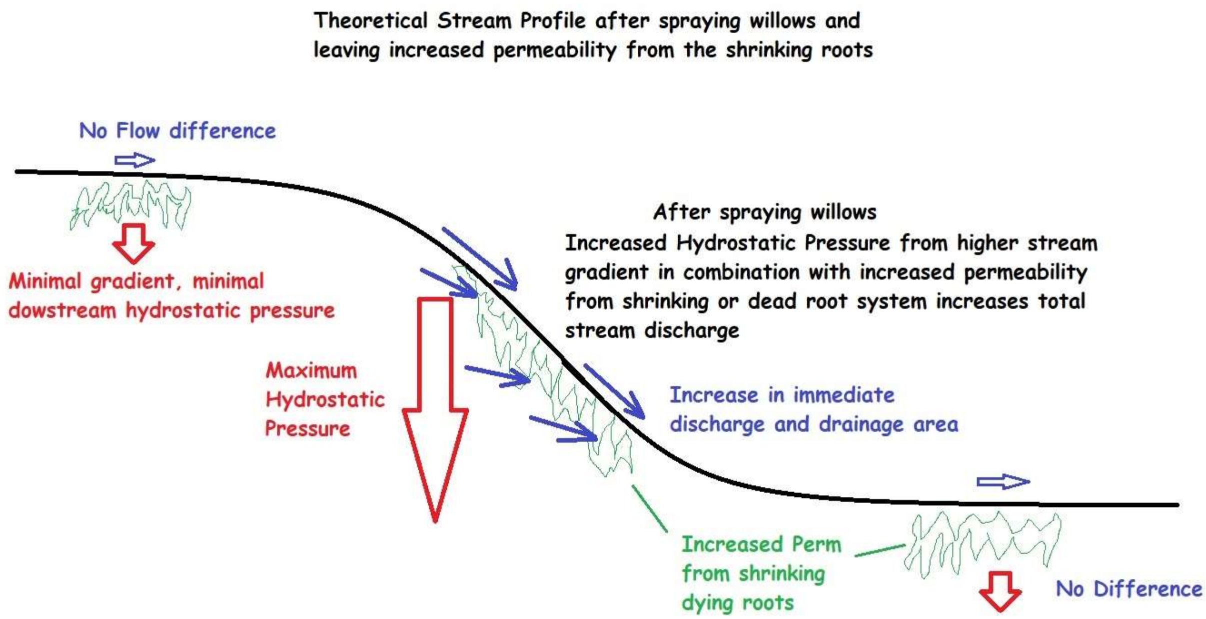


As well as decreasing the water moving through the stream segment by transpiration, it has other impacts as well. Overall each grove of willows behaves as a beaver dam, the thick root system decreases the permeability of the streambed backing up, storing, increasing the potential energy of the immediate area. Essentially the willow has evolved to hoard water for its own use.

Possibly many years ago, a large area was sprayed to control the willows and the water usage. This would be equivalent to knocking all of the beaver dams at one time. Root shrinkage would have increased permeability within the willow groves. This accelerated the drainage out of the storage area. Looking at it as a segment it would not have made any difference but if at the upper end, it would have accelerated the drainage from the storage area.

The two main factors affecting the drainage would be the stream gradient and the willow density. If there was no stream gradient, controlling the willows would not make any difference because the water wouldn't escape anyway. However, as stream gradient increases so does the downward hydrostatic pressure or hydrostatic gradient due to gravity. The higher the stream gradient, the more one must take caution on controlling the willows.

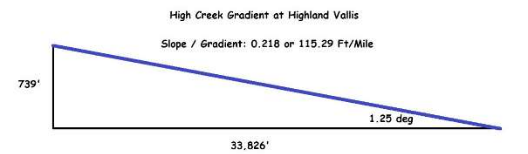
The following illustrations help to walk through the willow density and stream gradient.

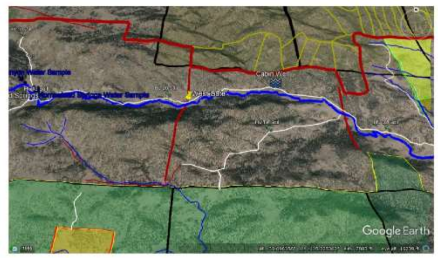


Willow Factor

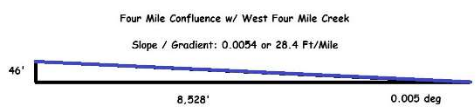
Willow Density & Stream Gradient

Stream Gradient





Stream Gradient (Hydrolic Gradient all other things equal) is 0.218/0.0054 or 40X Greater at High Creek at Highland Vallis Ranch than at the Confluence of Fourmile Creek and West Fourmile Creek located 5 miles to the north of Highland Vallis Ranch.



Willow Density

Sum the acres of willow groves along the same stream gradient from above.

For example use the following estimate:

Assume Willow Density is 6 acres of willows per mile of stream valley

Willow Factor Calculation

Highland Vallis Willow Factor: Willow Density / Stream Gradient

Willow Density: 6 Acres of Willows per linear mile of stream

Stream Gradient: 115 feet of elevation drop per linear mile of stream

Linear Mile of Stream: Length of stream with its meanders

Highland Vallis Willow Factor: 6/115 = 0.052 acres of willows per foot of fall

Highland Vallis Climate

Highland Vallis climate is a fantastic mountain climate with precipitation approximately 75% rain and 25% snow for a total of about 23 inches (58 cm) of precipitation per year. Summer high temperatures run about 70 to 75 degrees Fahrenheit (21-24C) while winter highs are about 40F (4-5C). Every winter evening is cool to cold but most of the really cold Canadian Arctic air (which is heavier and more dense) tends to stay at the lower elevation to the east on the plains. Highland Vallis' annual mean daily temperature is in the range of Chicago to San Francisco and about 15 degrees cooler than San Antonio and Austin, Texas.

Per the following chart, approximate half the year has a daily high of 70 degrees and daily low of just below 40. The cold season, the other half of the year, is just below 40 for a daily high and below 15 for a nightly low.

Highland Vallis Climate

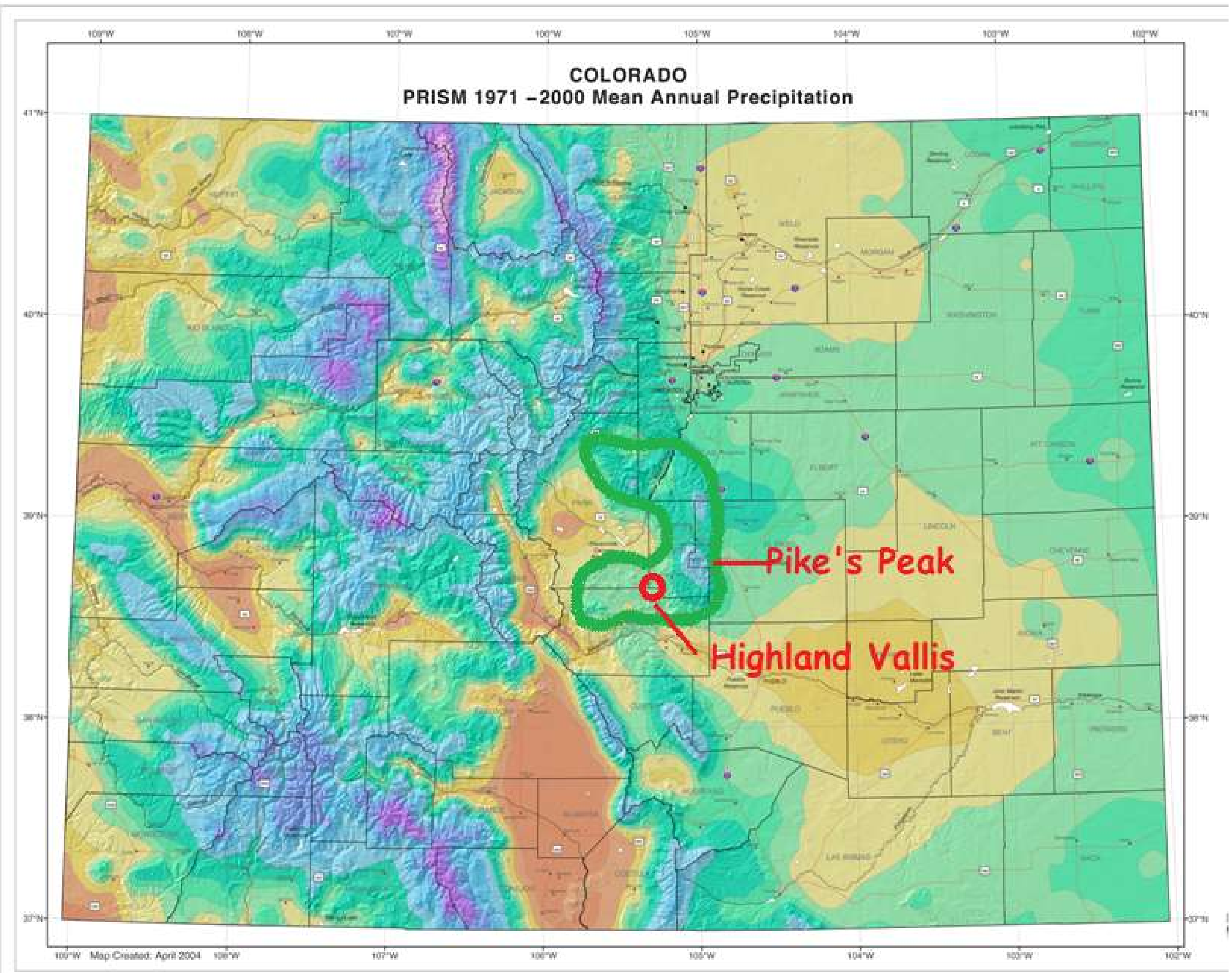
Weighted Average between Cripple Creek, Guffey and Canon City

Precipitation divided between Livestock Rotation Quarters

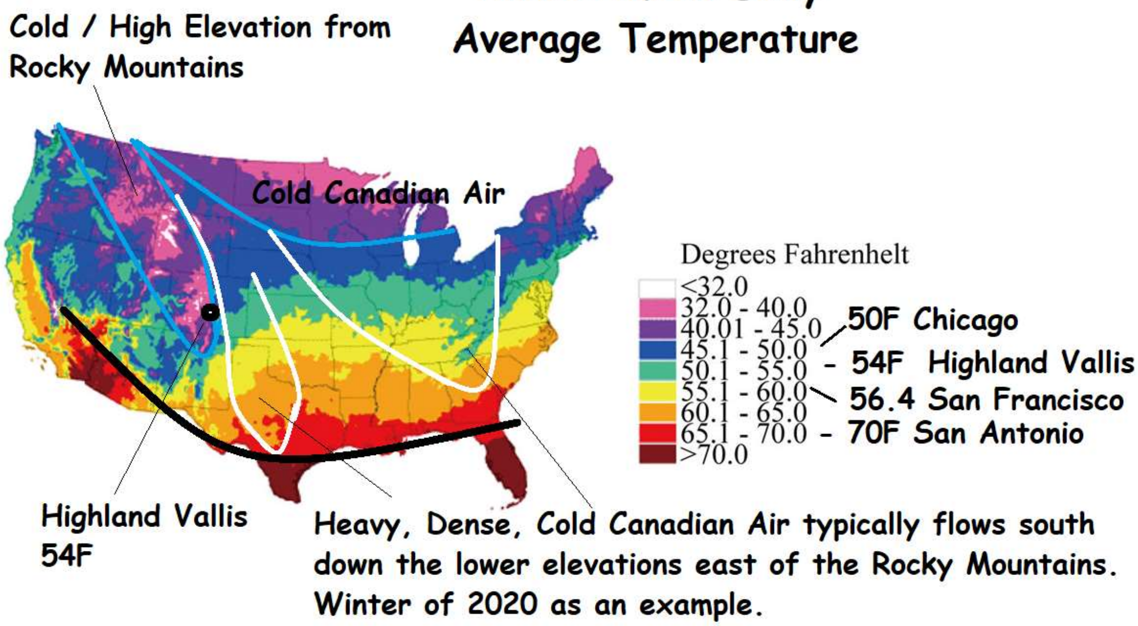
	Month / Livestock Quarter	High	Low	Rain	Snow		Avg High Temp	Avg Low Temp	Total Rain	Total Snow	Total Precip (assumes 10" snow per Inch of rain)	Percent of Precip
	February	35.4	8.2	0.66	8.114							
Livestock Quarter 1	March	44.4	15.4	1.076	9.274		43	15	3.58	26.98	6.28	27.36%
	April	50.2	22	1.842	9.59							
	May	60.4	31	2.172	2.246							
Livestock Quarter 2	June	71.6	40	1.652	0.096		69	39	6.63	2.34	6.87	29.94%
	July	76.4	46	2.808	0							
	August	73.4	44	2.662	0							
Livestock Quarter 3	September	67	36.4	1.468	0.592		65	35	5.13	5.20	5.65	24.65%
	October	55.4	25	1.004	4.61							
	November	43	15	0.686	5.318							
Livestock Quarter 4	December	33	6	0.586	8.302		37	9	1.88	22.56	4.14	18.04%
	January	34	6	0.61	8.936							
									17.23	57.08	22.93	100.00%

Highland Vallis is in an area referred to as the "Banana Belt" the area is a bit warmer and a bit less snow. The snow accumulates on the higher peaks in the area. Its "micro-climate" (climate associated with location and topography) appears to be controlled primarily by Pike's Peak topography. Both Pacific and Gulf of Mexico moisture tend to rise and condense in association with Pike's Peak.

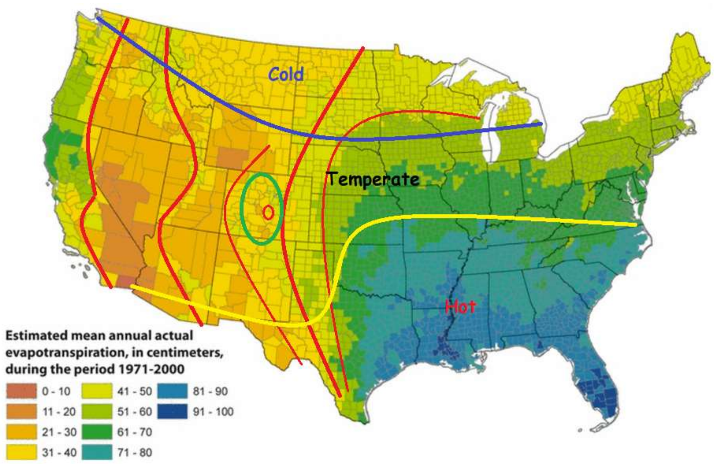
Additionally, probably due to the coarse soils and highly fractured bedrock, High Creek does not freeze and the snow on the ranch melts quickly.



Annual Mean Daily Average Temperature



Evapotranspiration maps are very insightful to evaluate a true climate. Factors include, precipitation, temperature, vegetation, elevation, topography, sunshine etc etc.



Evapotranspiration maps are very insightful to evaluate a true climate. Factors include, precipitation, temperature, vegetation, elevation, topography, sunshine.

The mountains of Western Colorado drive an anomolous wetter environment. Lift of humid air and water vapor over the mountains results in condensation and precipitation.

Annual Mean Total Precipitation

Finally, in considering long term climate changes the two most important factors during warming is to understand that increased heat increases evaporation (from the oceans) and warmer air can retain more water vapor. Together this means added water in the atmosphere. The mountains of Colorado are anomalous or wetter than would be normally predicted in the climate variations across the country. The reason for this is the mountains. As water vapor rises over the mountains, it is cooled and condenses into rain. The mountains also provide a cooler climate, from an agricultural standpoint Highland Vallis will benefit from a longer warmer growing season.

Regardless of the climate, the mountains are not going away which is the immediate and dominant control of the local environment and climate.

Summary - The migmatite, ignimbrite and tuff parent bedrock outcrops in the mountainous terrain of Highland Vallis Ranch are forming youthful soils and include mostly sand and silt sized granitic material (abundant feldspars) and much of clays that are present are of excellent quality such as vermiculite forming from both the ignimbrites and the biotite from the migmatites. This results in soils that have good infiltration rates which minimizes rapid runoff and erosion and provides good permeability for underground water movement. The high-quality clays provide high Cation Exchange Capacity (CEC). The CEC provides for good soil nutrient quality. This combination of bedrock, topography and soils with the moisture from both winter snows and summer showers provides for excellent native forages from forests to grasses. These forages are excellent for wildlife such as elk and mule deer to domesticated animals from cows to lamas.

Lubbock, Texas gets its good water from Ogallala water sands under the Great Plains of the US. The water from High Creek on Highland Vallis tests better than Lubbock city water. There are about half the constituents in Highland Vallis water as Lubbock water. The Highland Vallis primary water is melted snow and summer rain water migrating through the natural gravels and soils along High Creek. Moreover, because most of the water is running through subterranean porous and permeable gravels and soils, the water is not lost to evaporation and has developed a perfect natural irrigation system.

The combination of excellent soils and natural irrigation system (water) has provided for an excellent Desert Willow habitat which is an indicator species for a healthy Colorado environment. Being careful with the willow density and stream hydrostatic pressure (stream gradient) it would be nice to convert the Desert Willow environment into an orchard or vineyard environment.

Regardless of present indicators, the last glacial peak was about 30,000 years ago and the climate has been warming and melting glaciers since that time. It is likely that warming air temperatures will evaporate more sea water and carry more moisture. The moisture at Highland Vallis is derived primarily by condensation of moisture from both Gulf of Mexico and Pacific sources and that moisture is condensed into precipitation as the air is moved up onto the mountains. Further, a warming climate will lengthen and enhance the growing period of the area over time.