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by

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I. INTRODUCTION

In an effort to determine locatable bentonite deposits in the western United States, selected deposits were sampled in the Riverside District, BLM, during the summer of 1977. Shown in Figure 1 is an index map showing deposits examined. All of the bentonite localities sampled have had some past production, and all are currently under placer mining claims.

Samples were taken to determine the following characteristics:

1. Chemistry
2. Mineralogy
3. Physical Properties - Viscosity and Water Loss

This report, therefore, treats only the above properties of the bentonite and in no way is meant to be a validity determination of any of the deposits.

A. Sample Locations

1. Summit Range - San Bernardino County

   Sec. 29, 30, 31, 32, T28S, R41E

2. Gunn Deposit - San Bernardino County

   Sec. 22, T10N, R2E

3. El Centro - Imperial County

   Sec. 19, 20, 29, 30, T14S, R12E

4. Coyote Mountains - Imperial County

   Sec. 6, T16S, R9E

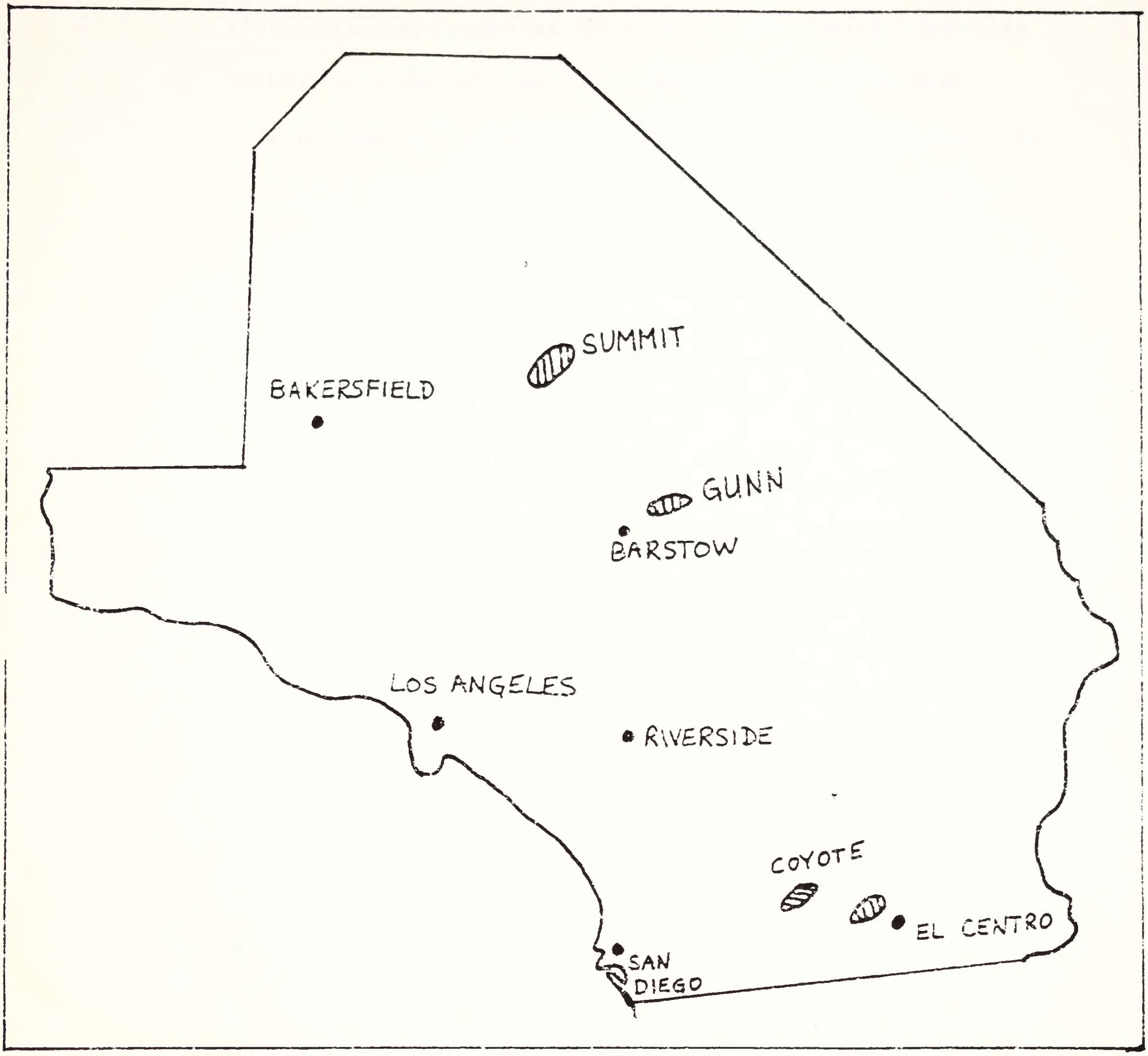


Figure 1. Index Map of Southern California Showing Sample Locations from Selected Bentonite Deposits. All Deposits Sampled are in Riverside District.

II. ANALYTICAL TECHNIQUES

A. X-Ray Diffraction Studies

All samples were examined for mineralogical phases, and clay content by x-ray diffraction. Samples were run by both oriented and unoriented techniques in order to show both clay mineralogy and general mineralogical content. The samples were scanned from 30°2θ down to 3°2θ at 2°2θ/minute. All x-ray diffraction interpretations were done by the author.

B. Exchangeable Chemistry

Selected samples were submitted to Coors Spectro-Chemical Labs for determination of their cation exchange capacity, exchangeable cations and soluble cations. Exchangeable and soluble cations determined were Na^+, K^+, Ca^{++} and Mg^{++}. In addition, Li^+ was determined on selected samples from the Summit Range and Gunn deposits.

C. Physical Properties

All of the samples collected were submitted to the BLM bentonite testing laboratory at Worland, Wyoming. Only viscosity and water loss tests were obtained since these two properties are most indicative of the chemistry of the bentonite and also its potential commercial value.

III. RESULTS

A. X-Ray Diffraction Analysis

Shown in Table I is the compilation of the major and minor mineralogical phases. Major phases were arbitrarily selected as those whose major diffraction line had an intensity which exceeded a scale of 50 on the XRD pattern. Minor phases had less than 50. The determination of Ca or Na montmorillonite was made by measurement of the (001) diffraction line. General guideline used consisted simply of calling all (001) reflections with spacings less than 6°2θ or greater than 14.7Å as calcium rich bentonite, and those with spacings greater than 6.5°2θ or less than 13.5 Å as high sodium bentonites. Bentonite with their (001) peaks between 6.0 and 6.5°2θ were simply referred to as intermediate or mixed Ca and Na bentonite. This procedure is not meant to be exact but only to indicate high sodium and calcium bentonites. The technique does appear to make this distinction, as shown by comparing the x-ray determination with the Na/CaMg ratios obtained on the samples.

As shown in Table 1, both of the sampled bentonite deposits in Imperial County are Ca bentonites. In addition, they contain high amounts of impurities, primarily quartz and calcite. Minor impurities include gypsum and feldspar minerals.

The bentonite sampled at the deposit in Summit Range varies from high Ca bentonite to a mixed calcium and sodium bentonite

Table 1. X-Ray Diffraction Analyses of Selected Bentonites from Southern California

Location	Major Phases	Minor Phases
Imperial County		
Coyote Mountains		
CA-CM-1	Ca Montmorillonite; Quartz	Calcite; Feldspar; Gypsum
CA-CM-2	" " ; "	" ; " ; "
CA-CM-3	" " ; "	" ; " ; "
El Centro		
CA-1-1	Ca Montmorillonite; Quartz; Calcite	Mica; Gypsum
CA-1-2	" " ; "	Calcite; Feldspar; Gypsum
CA-1-3	" : ; "	" ; " ; "
San Bernardino County		
Gunn Claims		
CA-G-1	Li-Mg Montmorillonite; Sepiolite	Quartz; Gypsum; Calcite
CA-G-J-1A	Na Montmorillonite	Quartz
CA-G-J-1B	Calcite	
CA-G-J-2	Gristobalite; Calcite	
CA-G-WT-1	Clinoptilolite	Unknown Zeolite??
CA-G-J-3	Ca Bentonite; Quartz	
CA-G-J-4	Calcite	
CA-G-J-5	Ca Bentonite	Gypsum; Quartz; Calcite
CA-G-J-5A	Ca Bentonite	Gypsum; Quartz; Calcite
CA-G-J-6	Na Bentonite	
Summit Range		
CA-RM-1	Na/Ca Montmorillonite; Cristobalite; Tridymite	
CA-RM-2	Ca Montmorillonite; Cristobalite; Tridymite	Quartz; Feldspar; Clinoptilolite
CA-RM-3	Na Montmorillonite; Cristobalite; Tridymite	Quartz; Feldspar; Clinoptilolite
CA-RM-4	Na Montmorillonite; Cristobalite; Tridymite	Feldspar; Calcite; Quartz
CA-RM-5	Na/Ca Montmorillonite; Cristobalite; Tridymite	Feldspar; Quartz, Clinoptilolite

to a Na bentonite. Major impurities in all the samples were cristobalite and tridymite. The zeolite, clinoptilolite, is a common contaminant of this deposit as well as quartz, calcite and feldspar minerals. The presence of cristobalite and tridymite would indicate that this bentonite was probably formed at a low temperature by diagenetic alteration.

The Gunn bentonite deposit is the most interesting in so far as its mineralogy is concerned. X-ray analysis indicates a suite of clay minerals which would indicate some low temperature hydrothermal activity. For example, one sample collected along a small fault zone was a mixture of sepiolite and hectorite. Also a sample collected just below its contact with the Pleistocene Alluvium is believed to be a very pure saponite. In addition, the Gunn deposit also contains zeolites, primarily clinoptilolite and a second zeolite not yet identified. The clinoptilolite occurs intermixed with the bentonite and also as somewhat pure monomineralic beds. Common impurities beside the zeolites are calcite, quartz and gypsum.

B. Chemistry

The exchangeable chemistry of the bentonites is an indication of their ion exchange capacities and also their potential swelling characteristics. It has been shown that predominantly sodium bearing bentonites have high swelling (viscosity) properties

while low sodium or high calcium bentonites have low viscosities. The chemistry then can be used as a guide for predicting the commerical application, if any, of the bentonite. Shown in Table 2 is the exchangeable chemistry of selected samples. The samples were selected for chemical analyses after the x-ray and physical property analyses were obtained, thus those samples selected were representative of the deposit.

The chemistry of the two deposits in Imperial County show that both are essentially high calcium bentonite deposits. The Na/CaMg ratios are very low, indicating an exchangeable calcium and magnesium content of 75 to 95%.

The bentonite deposit in the Summit Range is essentially an intermediate Na and Ca clay. Two samples had Na/CaMg ratios of 0.82 and 0.84 or a sodium content of 45-46%. The others had somewhat lower Na/CaMg ratios, thus approaching a high calcium type bentonite. One sample was also tested for exchangeable Li^+, which would indicate the highly desirable Li rich variety of bentonite known as hectorite. This sample showed only 0.05 meq/100 gm of Li^+ which would not indicate hectorite. The soluble Li^+ content was also very low.

The Gunn bentonite deposit is highly varied in its exchangeable chemistry, with the four samples tested having Na/CaMg ratios ranging from 1.9 down to 0.14. The sample with the high Na/CaMg ratio would indicate a high sodium bentonite of the type commonly

found in Wyoming. This deposit was also checked for Li^+ content because of its close proximity to the NL Industries hectorite deposit at Newberry Springs, California. Both samples showed less than 0.05 meq/100 gm of Li^+. The amount of soluble Li^+ was slightly higher, 2.0 meq/100 gm which may indicate Li enriched clays somewhere within the deposit.

C. Physical Properties

The viscosity and water loss values indicate the swelling characteristics of the bentonite. High swelling bentonites commonly find markets in the drilling mud, taconite and steel foundry industries. Low swelling bentonites commonly are used as animal feed binders, binders in the gray iron foundry markets, pond sealants and pet adsorbents. Water loss is also an indication of viscosity or swelling and also is a measure of potential use. Bentonites with high water loss values would be restricted in uses to much of the same markers as low swelling bentonites.

The physical properties of the bentonites are shown in Table 2 with the exchangeable chemistry. The deposits in Imperial County are low in viscosity and have very high water loss. Those in the Summit Range have viscosities from 30 to 70 bbl/ton and water loss values from 21 to 38 ml. This would indicate that the bentonite in the Summit Range may be a little more versatile in its uses because of its higher viscosity and lower water loss.

ʼable 2. Exchangeable Chemistry and Physical P ties of Selected Bentonites from Southern Cal ia

Location	Cation Exchange Capacity (meq/100 gm)	Chemistry (meq/100 gm) Na	K	Ca	Mg	Li	Na/CaMg	Physical Properties Viscosity	Water Loss (ml
Imperial County									
Coyote Mountains									
CA-CM-1	33.1	5.3	-	38.7	8.3	-	0.11	30	70
CA-CM-2	30.8	0.9	-	40.3	6.2	-	0.04	30	55
CA-CM-3	-	-	-	-	-	-	-	30	70
El Centro									
CA-I-1	38.3	9.3	-	22.4	6.2	-	0.04	30	122
CA-I-2	-	-	-	-	-	-	-	30	112
CA-I-3	31.8	1.3	0.7	40.3	5.1	-	0.33	40	55
San Bernardino County									
Gunn Claims									
CA-G-1	-	-	-	-	-	-	-	58	228
CA-G-J-1A	49.2	49.2	36.1	0.7	10.2	9.1	1.9	91	21
CA-G-J-1B	-	-	-	-	-	-	-	0	240) not
CA-G-J-2	-	-	-	-	-	-	-	0	148} bentoni
CA-G-WT-1	-	-	-	-	-	-	-	30	173 - zeolit
CA-G-J-3	37.5	3.9	0.1	24.1	3.2	<0.05	0.14	40	46
CA-G-J-5 (J&J)	59.9	29.5	-	50.2	3.1	-	0.55	30	107
CA-G-J-6	37.8	18.3	1.0	13.6	9.0	<0.05	0.85	80	33
*G-2-Jule	-	-	-	-	-	-	-	60	25
*G-3-Jule	-	-	-	-	-	-	-	54	17
*G-4-Jule	-	-	-	-	-	-	-	68	22
*G-9-Jule	-	-	-	-	-	-	-	39	16
*G-10-Jule	-	-	-	-	-	-	-	46	17
Summit Range									
CA-SH-1	46.7	11.5	0.5	36.6	2.3	<0.05	0.31	76	21
CA-SH-2	36.5	3.9	0.2	42.7	1.4	-	0.09	30	38
CA-SH-3	36.4	17.1	0.6	20.2	1.3	-	0.82	63	23
CA-SH-4	41.2	28.3	0.3	29.5	4.0	-	0.84	65	25
CA-SH-5	4313	11.7	0.3	43.1	3.5	-	0.26	55	23

* Physical properties taken from Ryman (1968).

The Gunn deposit varies widely in its physical properties because of its chemistry and mineralogy. It has zones of high viscosity bentonite and other areas where the viscosity is moderate to low. Water loss values are also highly variable, but generally are lower than for most Tertiary age bentonites.

IV. DISCUSSION

The four deposits samples in the Riverside District are all Tertiary age bentonites. The one deposit just west of El Centro is probably younger than the others and may even be early Pleistocene in age.

A. Imperial County Bentonite

This bentonite, using the classification proposed by Regis (1977) is of the high calcium type. Such a bentonite is somewhat restricted in usage to animal feed binders, pet adsorbents and other uses not requiring a swelling type bentonite.

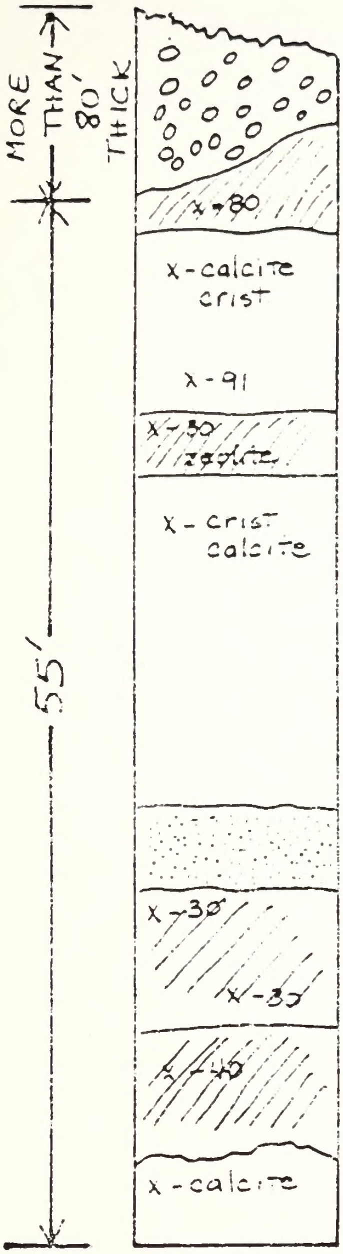
B. Summit Range Bentonite

This deposit would be classified as an intermediate or Ca-Na bentonite. There may be zones where the viscosity and water loss could make it valuable for drilling mud, taconite and steel foundry uses. Based on the samples taken from this deposit, however, its uses would be similar to those listed for the bentonite in Imperial County. In addition, this bentonite could find some markets as pond sealants, reservoir linings and possible some civil engineering applications.

C. Gunn Bentonite Deposit

This bentonite is highly variable in mineralogy, chemistry and physical properties. The samples collected at this deposit came from a 55 foot section of intermixed clay minerals, zeolites and calcite. Shown in Figure 2 is an idealized section of the deposit showing the relative sample localities. The thickness of this zone was measured from its upper contact with alluvium to the bottom of a long narrow excavation on the Jule claim, near the SE1/4 NW1/4 Sec. 22, T10N, R22E. This deposit appears to be an erosional remnant and was probably much larger in early Pleistocene time. The thickness of the Pleistocene overburden is variable, but in archeological control pit #1, the alluvium reaches a thickness of 77 feet, without reaching the tertiary sediments. Roughly outlined the bentonite exposures on aerial photographs, and using an average total thickness of all the bentonite beds, it is doubtful if more than 150,000 tons of bentonite occurs in this deposit, regardless of quality.

The classification of the Gunn bentonite would probably be similar to that in the Summit Range, an intermediate Ca-Na bentonite. The uses would be the same as discussed earlier. The low water loss values which the deposit appears to have would make it valuable for pond sealants. There may be zones of high Na bentonite, but the complexity of the whole sedimentary sequence could make a commercial venture costly.



Pliestocene alluvium - at least 80' thick.

Brownish bentonite and/or saponitic clay. At least 1' thick.

Very white zone. mixture of calcite, clay and quartz minerals. Approximately 10-15' thick.

Green bentonite, 1-2' thick.

Intermixed zone, at least 25' thick, made up of layers of toffaceous sandstone, shale, bentonite, zeolites.

Toffaceous sandstone. Approximately 5' thick.

White to gray to tan colored bentonite. Approximately 6' thick.

Green bentonite. Approximately 1-2' thick.

Silicious hot spring deposits - bottom not exposed. Some clay intermixed. At least 3' exposed.

Figure 2. Idealized Section Through Tertiary Sediment Zone. Location is approximately in the SE1/4 SW 1/4 Sec. 22, T10N, R2E.

x = sample localities and either x-ray phase or viscosity.

V. REFERENCES

Regis, A. J., Correlation Between Physical Properties and Exchangeable Chemistry of Bentonites from the Western United States. DSC Technical Note, BLM, Denver, Colorado, 1977.

Ryman, Michael E., Validity of Mining Claims of G. S. Gunn Conflicting with San Bernardino County Museum Archaeological Excavation. BLM Mineral Report, R1356, Riverside District, California, 6/11/68.