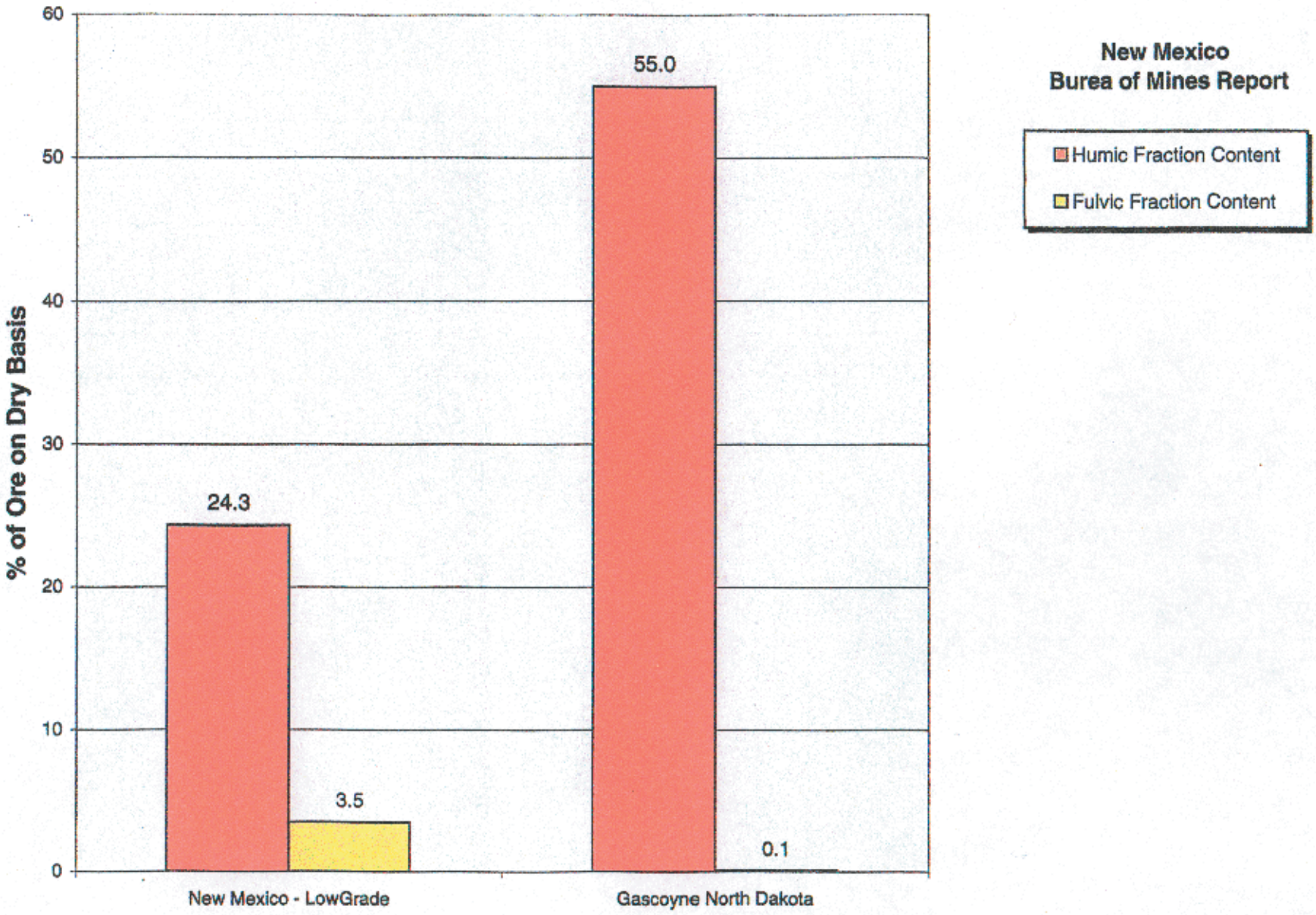
Functional Group Analyses

Conducted by Henri Dinel of the Canadian Soil Research Institute
Samples submitted November 12, 1998

Sample ID	Carboxyls (COOH) meq/g	Phenols (OH) meq/g	Ketones (CO) meq/g	Total Acidity meq/g
Mesa Verde New Mexico	1.5	5.8	5.8	7.3
Idaho	3.4	33.7	33.7	37.1
Typical Ranges for Humic	1.5 - 3.7	2.1 - 3.7	0.7 - 1.3	5.6 - 8.0
Typical Ranges for Fulvic	2.4 - 11.2	0.3 - 8.1	0.2 - 2.7	6.2 - 14.2


New Mexico
Burea of Mines Report
Humic Fraction Content
Fulvic Fraction Content
% of Ore on Dry Basis
60
50
40
30
20
10
0
24.3
3.5
55.0
0.1
New Mexico - LowGrade
Gascoyne North Dakota

Functional Group Analysis

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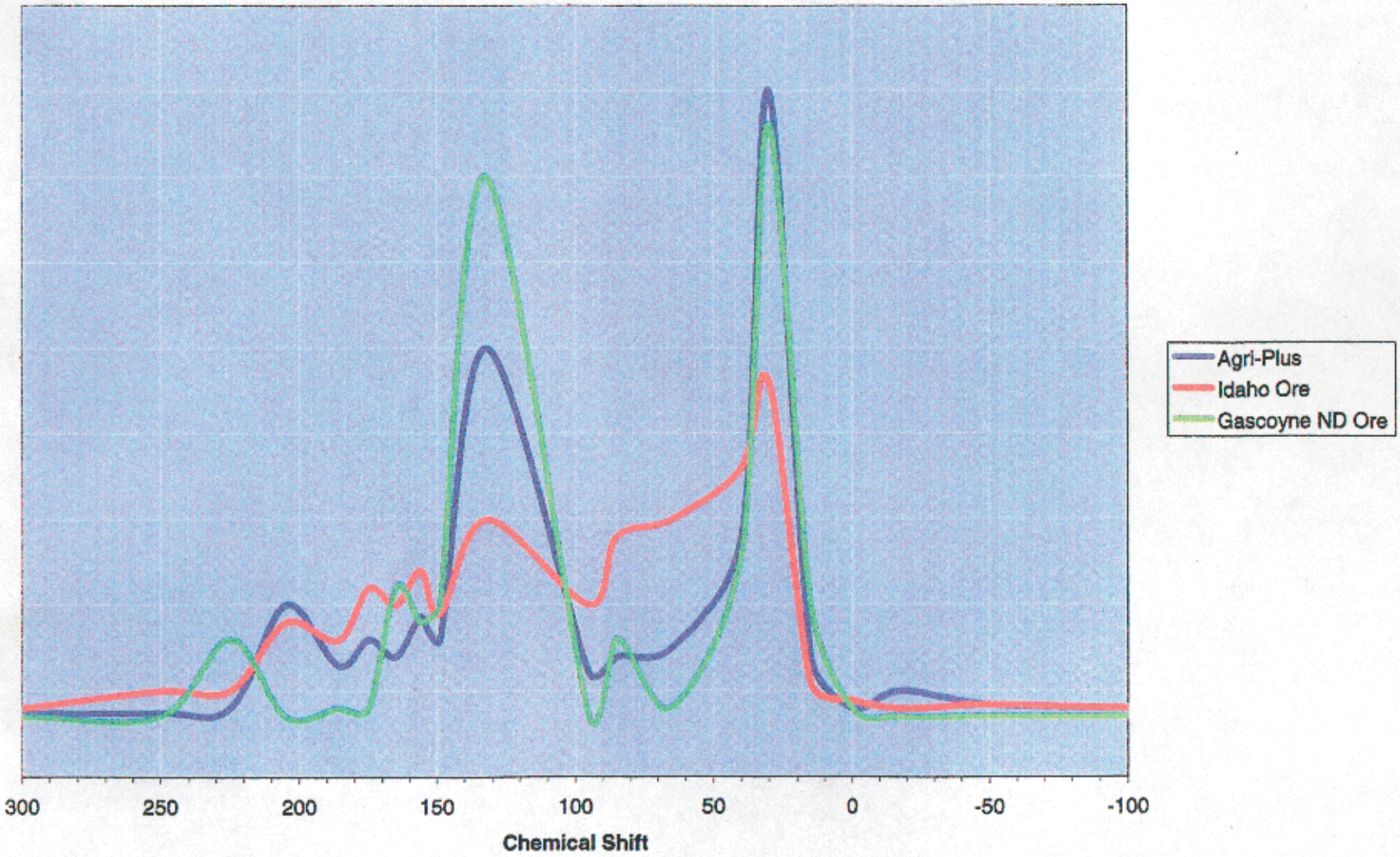
Table 1 - Report on Oven Dry Basis

Sample ID	Sample Description	Hydro-lyzable N mg/g	CEC meq/100g	CO %	COOH (Carboxyls) meq/g	OH (Hydroxyls) meq/g	Total Acidity meq/g	Humic Acids %
1	CA 97 High Grade	0.062	170	18.6%	1.62	10.83	11.31	35%
2	CA 98 High Grade	0.028	197	26.8%	1.58	9.39	10.96	32%
3	WA 98 High Grade	0.057	299	25.2%	3.09	1.64	4.73	46%
4	WA 97 Agri-Plus	0.072	239	25.7%	2.30	2.18	4.48	36%
5	WA 98 Agri-Plus	0.051	293	27.2%	2.04	2.20	4.25	41%
6	ID Bin A Sample 7	0.028	55	29.7%	1.17	0.33	1.50	5%
7	ID Bin B Sample 8	0.028	61	29.9%	1.64	0.21	1.84	4%
8	ID Milled Sample 9	0.036	42	26.1%	0.03	1.40	1.42	5%
9	ID Screen A	0.041	65	32.7%	0.27	0.97	1.24	3%
10	ID Screen B	0.061	57	34.1%	2.27	0.20	2.47	5%
11	Baroid	0.297	359	23.4%	1.86	4.58	6.45	63%
12	RSA	0.157	285	28.3%	1.83	4.14	5.96	80%

Table 2 - Report on Humic Acids Basis

Sample ID	Sample Description	Hydro-lyzable N mg/g	CEC meq/100g	CO	COOH (Carboxyls) meq/g	OH (Hydroxyls) meq/g	Total Acidity meq/g	Huffman Org. Mtr %
1	CA 97 High Grade	0.09	238	0.26	2.3	15.2	15.9	71%
2	CA 98 High Grade	0.04	310	0.42	2.5	14.8	17.2	64%
3	WA 98 High Grade	0.09	466	0.39	4.8	2.6	7.4	64%
4	WA 97 Agri-Plus	0.11	354	0.38	3.4	3.2	6.6	68%
5	WA 98 Agri-Plus	0.08	454	0.42	3.2	3.4	6.6	65%
	HRZ Avg.	*0.08*	*365*	*0.38*	*3.2*	*7.8*	*10.7*	*66%*
6	ID Bin A Sample 7	0.26	499	2.71	10.7	3.0	13.7	11%
7	ID Bin B Sample 8	0.25	537	2.65	14.5	1.9	16.3	11%
8	ID Milled Sample 9	0.30	343	2.16	0.2	11.6	11.7	12%
9	ID Screen A	0.35	555	2.78	2.3	8.3	10.6	12%
10	ID Screen B	0.53	492	2.94	19.6	1.7	21.3	12%
	ID Avg.	*0.34*	*485*	*2.65*	*9.5*	*5.3*	*14.7*	*12%*
11	*ND B*	*0.38*	*461*	*0.30*	*2.4*	*5.9*	*8.3*	*78%*
12	*ND R*	*0.21*	*388*	*0.39*	*2.5*	*5.6*	*8.1*	*73%*
	Typical Ranges for Humic				1.5 - 3.7	2.1 - 3.7	5.6 - 8.0	
	Typical Ranges for Fulvic				2.4 - 11.2	0.3 - 8.1	6.2 - 14.2	

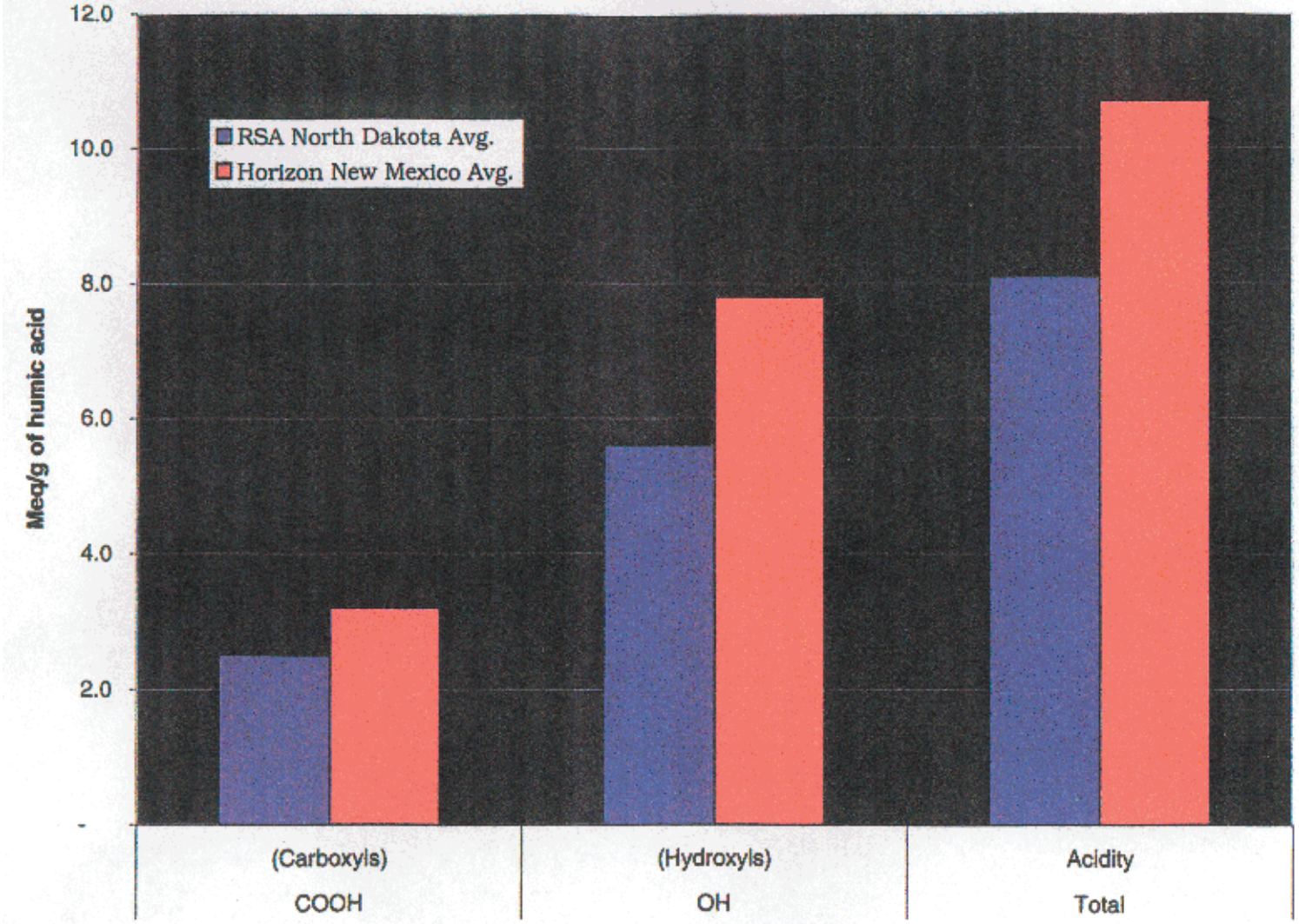
Carbon 14 NMR "Fingerprint" of Leonardite Ores



Summary of 1999, 2000, and 2001 Tests -Functional Group Results on Per Gram of Humic Basis

Sample Description	CEC meq/100g	CO Ketones meq/g	COOH (Carboxyls) meq/g	OH (Phenols) meq/g	Total Acidity meq/g
	365	**0.38**	***3.20***	***7.80***	***10.7***
	461	**0.30**	***2.50***	***5.60***	***8.1***
	388	**0.39**	***2.40***	***5.90***	***8.3***
	485	**2.65**	**9.50**	**5.30**	**14.7**
	N/A	**0.01**	***1.46***	***1.64***	***3.1***
	Typical range for humics		1.5 - 3.7	2.1 - 3.7	5.6 - 8.0
	Typical range for fulvics		2.4 - 11.2	0.3 - 8.1	6.2 - 14.2

Chart 1 - Functional Group Content of Several Humic Acids Sources



Reference: Chen, Y., Senesi, N., and M. Schnitzer. 1978. Chemical and physical characteristics of humic a

nd fulvic acids extracted from soils of the Mediteranean region. Geoderma 20:87-104

Ranges and means for elementary composition (%) and acidic groups (meq/g) of HA's and FA's

	Humic Acids			*Fulvic Acids*		
Elements (%)	Mean	Max	Min	Mean	Max	Min
Carbon	56.2%	58.7%	53.6%	45.7%	50.6%	40.7%
Hydrogen	4.7%	6.2%	3.2%	5.4%	7.0%	3.8%
Oxygen	33.6%	36.1%	30.2%	45.1%	49.9%	36.9%
Nitrogen	3.2%	5.5%	0.8%	2.7%	4.8%	0.9%
Sulfur	0.8%	1.5%	1.0%	1.9%	3.6%	1.0%
Acidic Groups:						
Total Acidity	6.7	7.7	5.6	10.3	14.2	6.4
Carboxyls	3.6	5.7	1.5	8.2	11.2	5.2
Phenolic OH	3.9	5.7	2.1	3.0	5.7	0.3

HA-Total Acidity	7.7	5.6	6.7
FA-Total Acidity	14.2	6.4	10.3
HA-Carboxyls	5.7	1.5	3.6
FA-Carboxyls	11.2	5.2	8.2
HA-Phenolic OH	5.7	2.1	3.9
FA-Phenolic OH	5.7	0.3	3.0

HA-Carbon	58.7%	53.6%	56.2%
FA-Carbon	50.6%	40.7%	45.7%
HA-Oxygen	36.1%	30.2%	33.6%
FA-Oxygen	49.9%	36.9%	45.1%