UIC - I - 8-1, 2 & 3

WDWs-1, 2 & 3 PERMITS, RENEWALS, & MODS (9 of 18)

2017

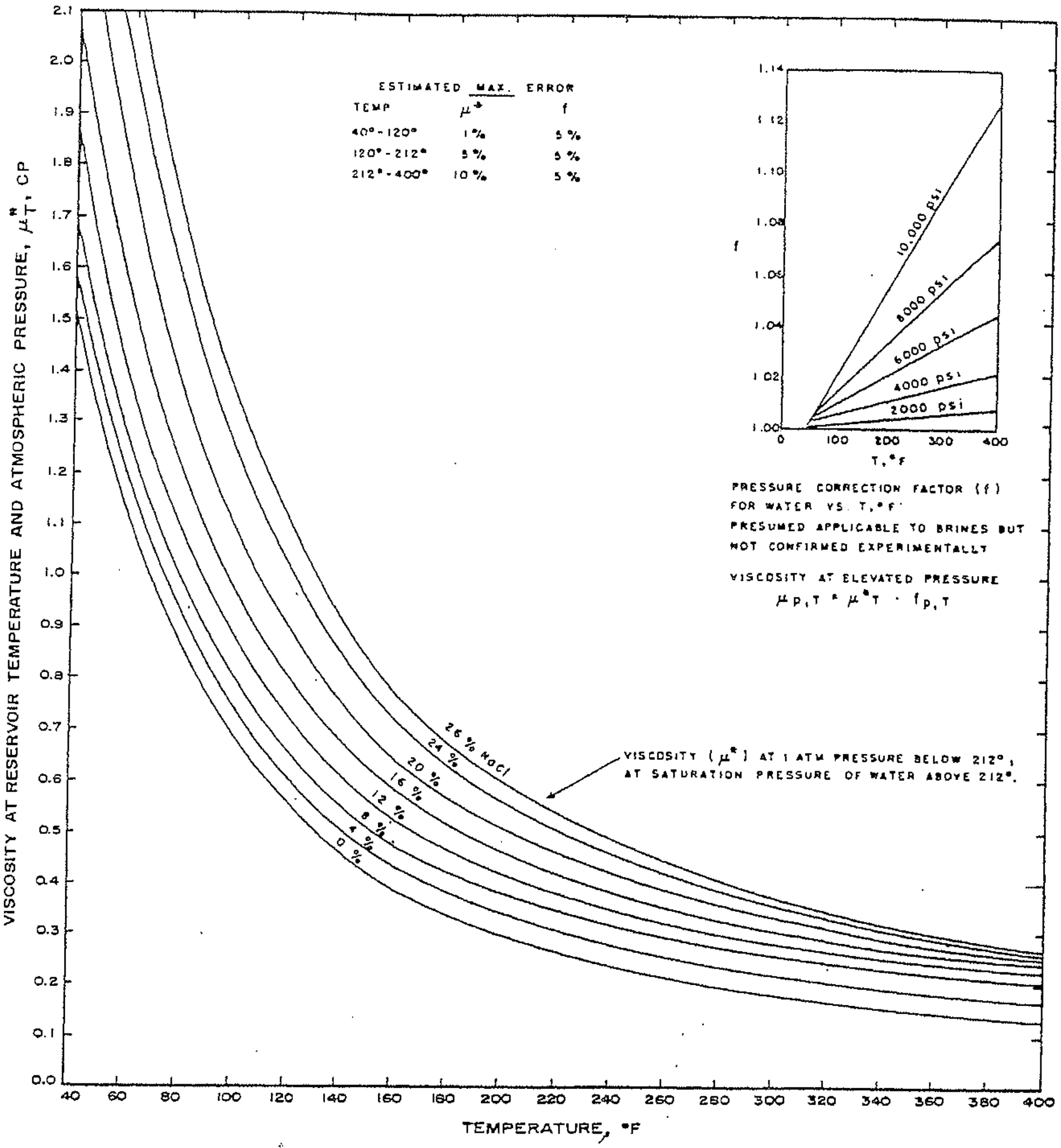

Fig. D.35 Water viscosity at various salinities and temperatures. After Matthews and Russell, data of Chesnut.[18]

FROM: Earlougher, R.C., 1977, "Advances in Well Test Analysis", SPE of AIME, Dallas, Texas

APPENDIX E-5

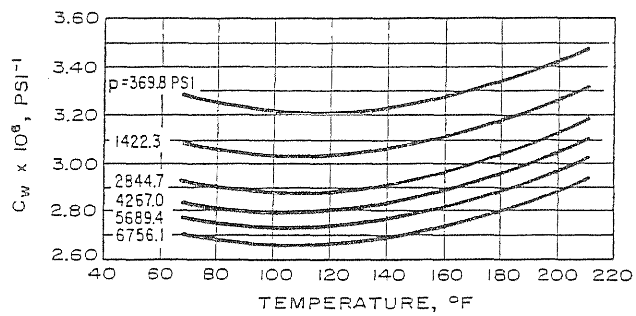

Fig. D.16 Average compressibility of distilled water. After Long and Chierici.[13]

Source: Earlougher, 1977, Advances in Well Test Analysis

COMPRESSIBILITY OF PORE VOLUME AND DISTILLED WATER

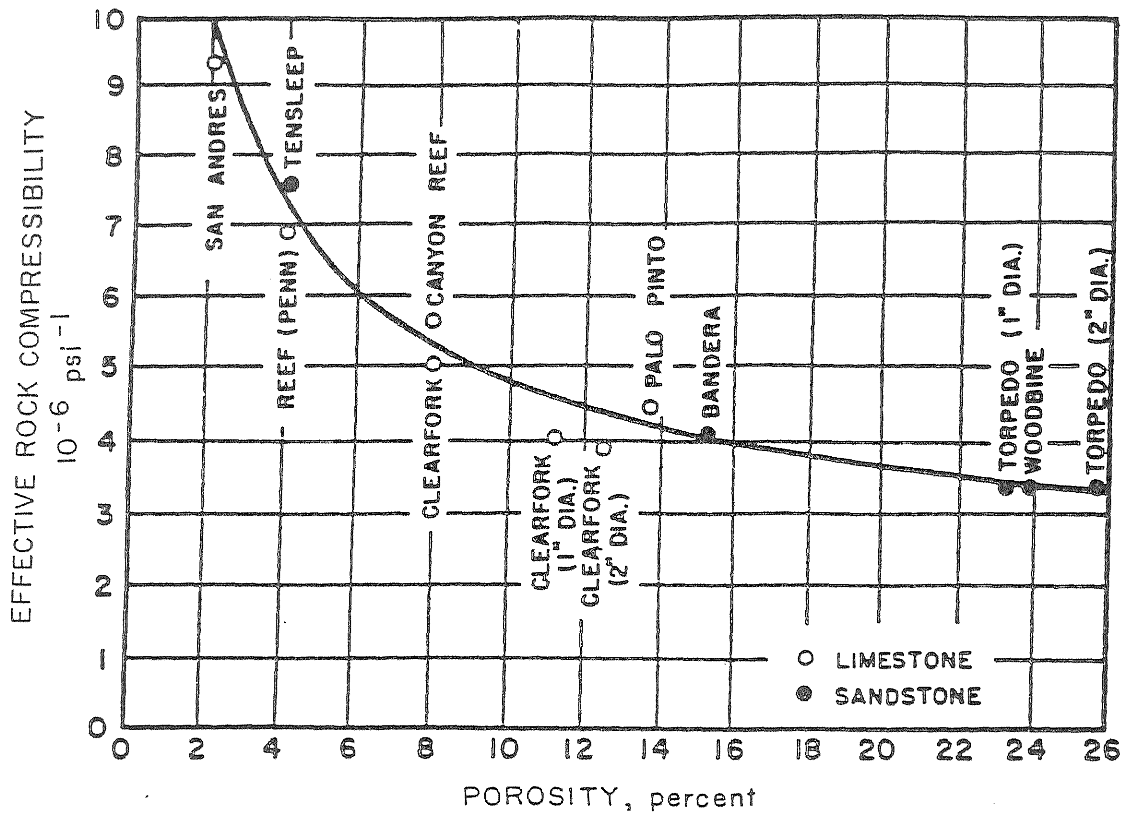

Fig. G.5 Effective formation (rock) compressibility. From Hall, *Trans.*, AIME (1953) 198, 309.

Source: Matthews and Russell, 1967, Pressure Buildup and Flow Tests in Wells

APPENDIX E-5

Predicted Increase in Bottomhole Pressure
Navajo Refining Company, L.L.C.

Permeability	251	md	Thickness	85	feet	Datum Depth: Well No. 1	7924	feet
Compressibility	8.40E-06	psi^{-1}	Porosity	10	%	Well No. 2	7570	feet
						Well No. 3	7660	feet

	Injection Rate Case A			Injection Rate Case B			Injection Rate Case C			Injection Rate Case D		
	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3
Injection Rate (gpm)	400	400	0	400	0	400	0	400	400	266.6	266.6	266.6

Date	Simulation Time	Increase in Bottomhole Pressure at Datum Depth (psi)											
		Injection Rate Case A			Injection Rate Case B			Injection Rate Case C			Injection Rate Case D		
(mm/dd/yyyy)	(days)	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3	Well No. 1	Well No. 2	Well No. 3
01/31/2017	6424	700.26	706.54	247.63	713.64	233.14	721.04	187.78	764.45	387.22	533.79	567.93	296.23
02/28/2017	6452	717.29	723.16	264.99	732.25	249.43	738.71	202.88	784.27	396.42	550.70	585.50	305.15
03/31/2017	6483	728.80	734.51	276.65	744.38	260.67	750.49	213.65	796.85	402.35	562.16	597.22	310.97
04/30/2017	6513	736.73	742.38	284.66	752.61	268.48	758.56	221.25	805.31	406.36	570.08	605.26	314.93
05/31/2017	6544	743.11	748.72	291.09	759.18	274.79	765.02	227.42	812.01	409.56	576.45	611.71	318.09
06/30/2017	6574	748.17	753.75	296.19	764.36	279.80	770.14	232.34	817.28	412.07	581.50	616.81	320.58
07/31/2017	6605	752.60	758.17	300.64	768.88	284.20	774.61	236.67	821.86	414.26	585.93	621.28	322.75
08/31/2017	6636	756.44	761.99	304.50	772.79	288.01	778.48	240.44	825.82	416.15	589.76	625.14	324.63
09/30/2017	6666	759.73	765.27	307.80	776.12	291.28	781.79	243.67	829.19	417.76	593.04	628.44	326.24
10/31/2017	6697	762.77	768.30	310.86	779.21	294.31	784.85	246.67	832.30	419.25	596.09	631.50	327.72
11/30/2017	6727	765.45	770.97	313.54	781.91	296.97	787.54	249.30	835.03	420.56	598.76	634.18	329.03
12/31/2017	6758	767.97	773.49	316.07	784.47	299.48	790.08	251.80	837.61	421.80	601.28	636.72	330.26
01/31/2018	6789	770.30	775.81	318.41	786.82	301.80	792.42	254.10	839.98	422.93	603.61	639.05	331.39
02/28/2018	6817	772.26	777.77	320.37	788.79	303.75	794.38	256.04	841.96	423.89	605.56	641.02	332.34
03/31/2018	6848	774.28	779.79	322.40	790.84	305.77	796.42	258.05	844.02	424.87	607.59	643.05	333.32
04/30/2018	6878	776.12	781.62	324.25	792.69	307.61	798.26	259.87	845.89	425.77	609.43	644.89	334.21
05/31/2018	6909	777.91	783.41	326.04	794.50	309.39	800.06	261.64	847.70	426.64	611.21	646.69	335.08
06/30/2018	6939	779.55	785.04	327.68	796.14	311.02	801.70	263.27	849.36	427.44	612.85	648.33	335.88
07/31/2018	6970	781.15	786.65	329.29	797.76	312.62	803.31	264.86	850.98	428.21	614.45	649.94	336.65
08/31/2018	7001	782.68	788.17	330.81	799.29	314.14	804.84	266.37	852.52	428.95	615.98	651.46	337.39
09/30/2018	7031	784.09	789.57	332.22	800.71	315.55	806.25	267.77	853.94	429.64	617.38	652.87	338.07
10/31/2018	7062	785.48	790.96	333.61	802.11	316.93	807.64	269.15	855.35	430.31	618.77	654.26	338.75
11/30/2018	7092	786.76	792.25	334.90	803.40	318.22	808.94	270.43	856.65	430.94	620.06	655.55	339.37
12/31/2018	7123	788.04	793.52	336.18	804.69	319.49	810.22	271.70	857.94	431.56	621.33	656.83	339.99
01/31/2019	7154	789.27	794.75	337.41	805.92	320.72	811.45	272.92	859.17	432.15	622.56	658.06	340.58
02/28/2019	7182	790.34	795.82	338.49	807.00	321.79	812.52	273.99	860.25	432.67	623.63	659.14	341.10
03/31/2019	7213	791.48	796.96	339.63	808.14	322.93	813.67	275.12	861.41	433.23	624.77	660.28	341.65
04/30/2019	7243	792.55	798.03	340.70	809.22	324.00	814.74	276.19	862.48	433.74	625.84	661.35	342.17
05/31/2019	7274	793.62	799.10	341.77	810.29	325.06	815.81	277.25	863.56	434.26	626.91	662.42	342.69
06/30/2019	7304	794.62	800.10	342.78	811.30	326.06	816.81	278.25	864.57	434.75	627.91	663.43	343.17
07/31/2019	7335	795.63	801.10	343.78	812.31	327.07	817.82	279.25	865.58	435.23	628.92	664.43	343.66
08/31/2019	7366	796.60	802.08	344.76	813.28	328.04	818.79	280.22	866.56	435.70	629.89	665.41	344.13
09/30/2019	7396	797.52	802.99	345.67	814.20	328.95	819.71	281.13	867.48	436.15	630.81	666.32	344.57
10/31/2019	7427	798.44	803.91	346.59	815.13	329.87	820.63	282.05	868.41	436.59	631.73	667.24	345.01
11/30/2019	7457	799.31	804.78	347.46	816.00	330.74	821.50	282.91	869.28	437.01	632.59	668.11	345.43
12/31/2019	7488	800.18	805.65	348.34	816.87	331.61	822.38	283.78	870.16	437.44	633.47	668.99	345.86
01/31/2020	7519	801.03	806.50	349.19	817.73	332.46	823.23	284.63	871.01	437.85	634.32	669.84	346.27
02/29/2020	7548	801.81	807.28	349.97	818.51	333.24	824.01	285.40	871.80	438.22	635.09	670.61	346.64
03/31/2020	7579	802.62	808.09	350.78	819.32	334.05	824.82	286.21	872.61	438.61	635.90	671.43	347.03
04/30/2020	7609	803.38	808.85	351.54	820.09	334.81	825.59	286.98	873.38	438.99	636.67	672.19	347.40
05/31/2020	7640	804.16	809.63	352.32	820.87	335.59	826.36	287.75	874.16	439.36	637.44	672.97	347.78
06/30/2020	7670	804.89	810.36	353.05	821.60	336.32	827.10	288.48	874.90	439.72	638.18	673.70	348.13
07/31/2020	7701	805.63	811.10	353.80	822.35	337.06	827.84	289.22	875.64	440.07	638.92	674.44	348.49
08/31/2020	7732	806.36	811.83	354.52	823.07	337.79	828.57	289.94	876.37	440.42	639.64	675.17	348.84
09/30/2020	7762	807.05	812.52	355.21	823.76	338.47	829.26	290.63	877.06	440.76	640.33	675.86	349.17
10/31/2020	7793	807.75	813.21	355.91	824.46	339.17	829.96	291.33	877.77	441.09	641.03	676.56	349.51
11/30/2020	7823	808.41	813.88	356.57	825.13	339.83	830.62	291.99	878.43	441.41	641.69	677.22	349.83
12/31/2020	7854	809.08	814.55	357.25	825.80	340.50	831.29	292.66	879.10	441.74	642.36	677.89	350.15
01/31/2021	7885	809.74	815.21	357.90	826.46	341.16	831.95	293.31	879.77	442.06	643.02	678.55	350.47
02/28/2021	7913	810.32	815.79	358.49	827.05	341.74	832.54	293.90	880.35	442.34	643.60	679.14	350.75
03/31/2021	7944	810.96	816.43	359.13	827.68	342.38	833.17	294.53	880.99	442.65	644.24	679.77	351.06
04/30/2021	7974	811.56	817.03	359.73	828.29	342.98	833.78	295.13	881.60	442.94	644.85	680.38	351.35
05/31/2021	8005	812.18	817.65	360.35	828.91	343.60	834.39	295.75	882.22	443.24	645.46	680.99	351.65
06/30/2021	8035	812.76	818.23	360.93	829.49	344.18	834.98	296.33	882.80	443.52	646.04	681.58	351.93
07/31/2021	8066	813.36	818.82	361.53	830.09	344.78	835.57	296.92	883.40	443.81	646.64	682.17	352.22
08/31/2021	8097	813.94	819.41	362.11	830.68	345.36	836.16	297.51	883.99	444.09	647.22	682.76	352.50
09/30/2021	8127	814.50	819.97	362.67	831.23	345.92	836.72	298.06	884.55	444.36	647.78	683.32	352.77
10/31/2021	8158	815.07	820.53	363.24	831.80	346.49	837.29	298.63	885.12	444.63	648.35	683.88	353.04
11/30/2021	8188	815.61	821.07	363.78	832.34	347.03	837.83	299.17	885.66	444.89	648.89	684.43	353.30
12/31/2021	8219	816.16	821.62	364.33	832.90	347.58	838.38	299.72	886.21	445.16	649.44	684.98	353.57

APPENDIX E-6

Predicted Plume Calculations

Plume with Dispersion (Warner and Lehr - 1977)

$$r_{waste} = \sqrt{\frac{0.1337\,V}{\pi h(0.8\,\phi)}}$$

where

r_{waste}	=	radial distance of waste front (feet)
0.1337	=	factor to convert gallons to cubic feet
V	=	cumulative volume of injected wastewater (gallons)
h	=	reservoir thickness (feet)
$0.8\,\phi$	=	effective porosity

$$r_{dispersed} = r_{waste} + 2.3\sqrt{D\,r_{waste}}$$

where

$r_{dispersed}$	=	radial distance of waste front with dispersion (feet)
D	=	dispersion coefficient; 3 ft for sandstone and 65 ft for carbonate

using the following parameters:

ϕ	=	0.1
h	=	85
D	=	65

	Current Plume Size (January 1, 2017)			Plume Size at End of Permit Period (+5 Years)		
	V	r_{waste}	$r_{dispersed}$	V	r_{waste}	$r_{dispersed}$
	Total Volume Injected (gallons)	Radial Distance of Waste Front (feet)	Radial Distance of Waste Front with Dispersion (feet)	Total Volume Injected (gallons)	Radial Distance of Waste Front (feet)	Radial Distance of Waste Front with Dispersion (feet)
Well 1 (Mewbourne)	1,658,353,240	3222	4274	2,709,553,240	4118	5308
Well 2 (Chukka)	1,196,702,400	2737	3707	2,247,902,400	3751	4886
Well 3 (Gaines)	683,350,989	2068	2911	1,734,550,989	3295	4359

APPENDIX F-1

FORMATION FLUID ANALYTICAL DATA
NAVAJO REFINING COMPANY, L.L.C.
ARTESIA, NEW MEXICO

Chemical	Mewbourne Well No. 1	Chukka Well No. 2	Gaines Well No. 3	Average
Date	July 31, 1998	June 14, 1999	Nov 8, 2006	
Fluoride (mg/l)	2.6	9.7	Not Detected	6.15
Chloride (mg/L)	19,000	15,000	10,447	14,815.67
NO3-N (mg/L)	<10	<10	--	<10
SO4 (mg/L)	2,200	2000	1,908	2,036
CaCO3 (mg/L)	1000	1210	--	1105
Specific Gravity (g/L)	1.034	1.0249	--	1.0295
TDS (mg/L)	33,000	20,000	--	26,500
Specific Conductance (uMHOs/cm)	52,000	43,000	--	47,500
Potassium (mg/L)	213	235	85.5	177.83
Magnesium (mg/L)	143	128	155	142
Calcium (mg/L)	390	609	393	464
Sodium (mg/L)	12,770	8,074	6,080	8,974.67
pH (s.u.)	8.1	7.2	--	7.65

The data in the above table was referenced from "Discharge Plan Application and Application for Authorization to Inject per Oil Conservation Division Form C-108, into Class I Wells WDW-1 and Proposed WDW-2 and WDW-3" and the "Discharge Permit Approval Conditions", "Reentry and Completion Report Waste Disposal Well No. 2", and "Reentry and Completion Report Waste Disposal Well No. 3".

COMPATABILITY STUDY
NAVAJO REFINING COMPANY

Artesia, New Mexico

December 2016

PB Energy Storage Services
Houston, TX

A Company of

WSP | PARSONS BRINCKERHOFF

Project No. 50904B

Prepared by Brenda Love Reviewed by Oliver Man

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1.0 Compatibility Analyses

Compatibility tests for Navajo's waste stream were performed by analyzing the chemical reactions between different mixtures of the secondary reverse osmosis reject fluid and the waste water and flue gas scrubber mixture. All testing and analysis were performed by Intertek Group PLC (Intertek) who provide chemical testing and analyses to understand the composition of chemical substances and materials that are used in products, industrial processes and manufacturing. Intertek is located in Houston, Texas. Intertek's report is included as Attachment 1.

2.0 Analyzed Waste Streams

The waste stream to be injected into the waste disposal wells will be comprised of three different fluids from the different processes in the refinery: Secondary Reverse Osmosis reject (SRO), Flue Gas Scrubber fluid (FGS), and Waste Water and Flue Gas Scrubber fluid (WWFGS). Since Navajo can't separate the waste water from the flue gas scrubber fluid prior to injecting it, an analysis of the waste water could not be performed.

2.1 Secondary Reverse Osmosis Reject Stream

The SRO was synthesized by taking the existing Reverse Osmosis (RO) reject and evaporating this fluid to 75% of the existing volume of the RO. This reduction left behind a large amount of residue as shown in Figure 1. After the initial evaporation to create the SRO, the SRO was filtered through a 0.45 micron filter. The residue leftover after the filtering process was tested as "pretest" material and was analyzed using the scanning electron microscope (SEM). A copy of Intertek's SEM analyses of the pretest SRO material is included as Table 1.

2.2 Flue Gas Scrubber Fluid

The FGS fluid was milky in color with a large amount of suspended solids. The color and amount of suspended solids in the FGS is because the FGS is not being treated through the knockout boxes and centrifuges. Before testing, the FGS was filtered through a 0.45 micron filter. The suspended solids content was 0.97 grams/liter. The SEM analysis of the pretest FGS is included in Table 2. The FGS fluid is shown in Figure 2, Figure 3, and Figure 4.

2.3 Wastewater and Flue Gas Scrubber Mix

The final fluid provided to the lab for testing was the WWFGS fluid. Prior to Navajo mixing the FGS with the wastewater the suspended solids in the FGS are removed using two knockout boxes and a centrifuge. As a result of this process, the WWFGS is clearer and contains considerably less suspended solids as compared to the FGS. The WWFGS is shown in Figure 5.

3.0 Mass Concentration of the Precipitates of SRO, FGS, and WWFGS

The blends of injectate tested were as follows:

- 100% SRO
- 100% FGS
- 100% WWFGS
- 75%:25% SRO:FGS
- 50%:50% SRO:FGS
- 25%:75% SRO:FGS
- 75%:25% SRO:WWFGS
- 50%:50% SRO:WWFGS
- 25%:75% SRO:WWFGS

Each blend was put into a one liter stainless steel piston cylinder and brought to downhole conditions of 150°F at a pressure of 5000 psi and left undisturbed for 20 days. After 20 days, the vessels were gradually brought back to surface conditions in which the pressure was bled off and allowed to cool to ambient room temperature. The solutions were then run through a 0.45 micron filter to capture any precipitate that may have formed during the incubation period. After filtration, any solids which precipitated out of solution were weighed and subsequently analyzed using the SEM.

The mass concentration of the precipitates along with photographs of the precipitated solids are presented in Table 3. The anticipated waste stream to be injected will be a blend of the SRO and WWFGS. As shown in the Table 3, the mixture of the anticipated waste stream with the least amount of suspended solids was the 50:50 SRO:WWFGS at 0.4050 grams/liter followed by the 25:75 SRO:WWFGS at 0.4450 grams/liter and then the 75:25 SRO:WWFGS at 0.4667 grams/liter.

4.0 SEM of SRO, FGS, and WWFGS

The samples precipitated out of solution were analyzed using the SEM. The weight percent of the individual elements of the SRO, FGS, and WWFGS prior to mixing are shown in Table 4, Table 5, and Table 6, respectively. The weight percent of the individual elements of the solids precipitated out of the different blends of the tested fluids described in Section 3.0 are shown in Table 7.

5.0 Acid Solubility of SRO, FGS, and WWFGS

Acid solubility testing was conducted using the samples of the precipitates described in Section 3.0.

A known amount of solids were placed in 20 milliliter glass vials to which a minimum of 2 milliliters of 37% concentrated hydrochloric acid (HCl) was added. The vials were allowed to sit undisturbed for three days. After three days, the samples were photographed and filtered to remove any residual solids. Any residual solids recovered were dried overnight at 105°F, then cooled to room temperature and weighed both before being treated with acid and then after being treated with acid. The results of the acid solubility testing are shown in Table 8.

With the exception of the pretest SRO and pretest WWFGS solutions it appears that all of the solids filtered from the different combinations of the tested fluids were, for the most part, completely dissolved in the HCl acid. Periodic acid stimulation of the disposal wells will therefore be a viable option for controlling potential skin issues in the wellbore.

6.0 Conclusions

In conclusion, all of the waste streams tested precipitated some amount of solids out of solution. The anticipated waste stream to be injected into the disposal wells will be a combination of the SRO and WWFGS (SRO:WWFGS). The waste stream mixture that yielded the least amount of suspended solids was the 50:50 SRO:WWFGS mix, which yielded 0.4050 grams/liter of precipitate followed by the 25:75 SRO:WWFGS at 0.4450 grams/liter, and finally the 75:25 SRO:WWFGS at 0.4667 grams/liter.

All of the different combinations of the tested fluids were, for the most part, completely dissolved using between 2 milliliters and 8 milliliters of 37% HCl acid. Only the SRO pretest solids and the FGS pretest solids were not totally acid soluble.

It is reasonable to conclude that the precipitates formed from all of the mixtures tested can be dissolved by periodically acidizing the formation receiving the waste stream. By dissolving the precipitates through acidization the overall life of the well should not be adversely affected.

Because of the acid solubility of the precipitates formed during the testing, additional studies should be conducted to determine if adjusting the pH of the fluid will reduce the amount of solids that precipitate out of the injectate prior to injecting the waste fluids into the disposal wells.

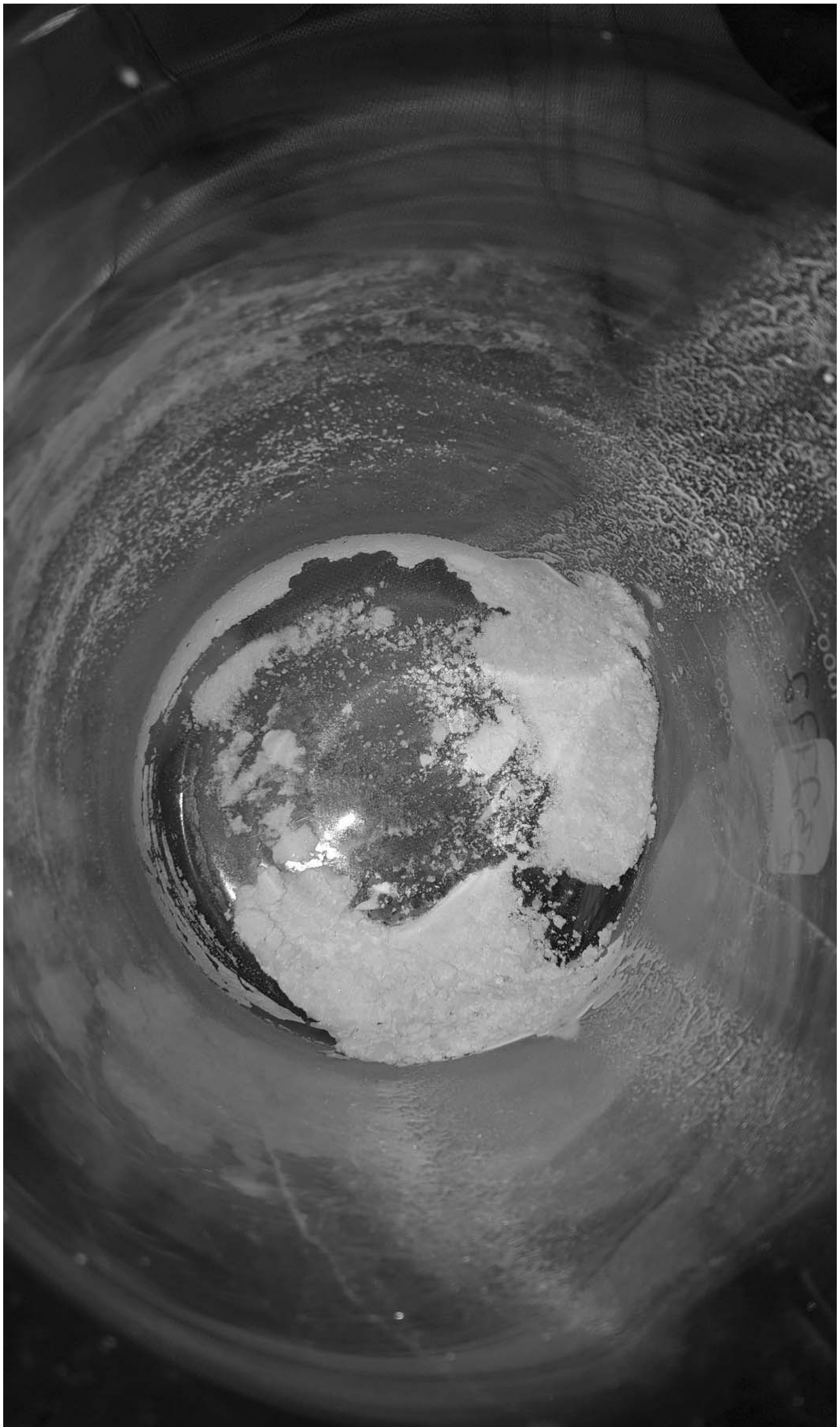

FIGURE 1: SRO Residue After Evaporation

FIGURE 2: FGS Sample Prior to Initial Filtering

FIGURE 3: FGS Filtering Process

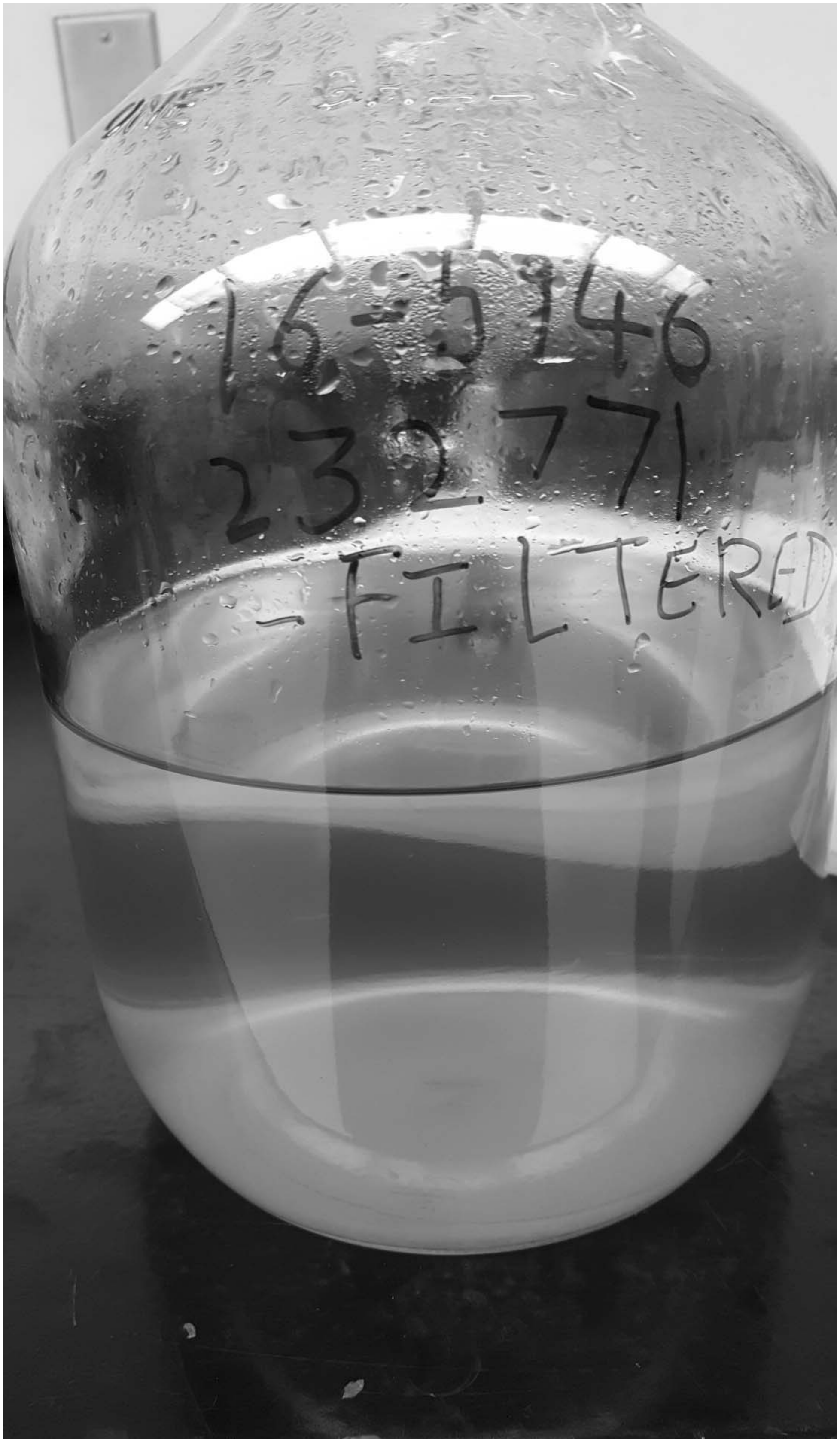

FIGURE 4: FGS After Filtering

FIGURE 5: WWFGS Fluid from the Plant

TABLE 1: SEM Analysis of the Pretest SRO Sample

Navajo Waste Stream Characteristics	
Element	Weight Percent
Oxygen	56.91
Calcium	22.13
Sulfur	13.93
Carbon	2.97
Magnesium	2.14
Silicon	1.92
Nitrogen	0.00
Fluorine	0.00
Sodium	0.00
Aluminum	0.00
Phosphorus	0.00
Chloride	0.00
Chromium	0.00
Manganese	0.00
Titanium	0.00

TABLE 2: SEM Analysis of the Pretest FGS Sample

Navajo Waste Stream Characteristics	
Element	Weight Percent
Oxygen	39.39
Aluminum	27.94
Silicon	22.00
Sulfur	21.00
Lanthanum	2.79
Carbon	2.47
Magnesium	1.91
Cerium	1.35
Iron	0.76
Sodium	0.54
Titanium	0.44
Calcium	0.20
Nitrogen	0.00
Fluorine	0.00
Phosphorus	0.00

TABLE 3: Mass Concentration of the Precipitated Solids

Test	Mass Concentration (grams/liter)
50:50 SRO:FGS	0.9083
75:25 SRO:FGS	0.8033
100% SRO	0.6217
100% WWFGS	0.5267
75:25 SRO:WWFGS	0.4667
25:75 SRO:WWFGS	0.4450
25:75 SRO:FGS	0.4050
50:50 SRO:WWFGS	0.4050
100% FGS	0.3750

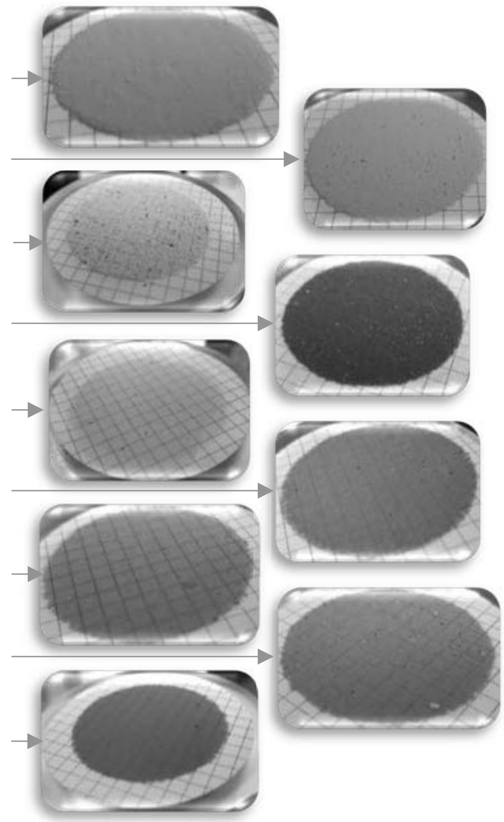

TABLE 4: SEM Analysis of the SRO Sample

Navajo Waste Stream Characteristics	
Element	Weight Percent
Element	
Oxygen	45.52
Calcium	21.5
Carbon	9.05
Nickel	8.23
Silicon	6.87
Magnesium	4.40
Sulfur	3.72
Iron	0.51
Phosphorus	0.20
Nitrogen	0.00
Fluorine	0.00
Sodium	0.00
Aluminum	0.00
Chloride	0.00
Chromium	0.00

TABLE 5: SEM Analysis of the FGS Sample

Navajo Waste Stream Characteristics	
Element	Weight Percent
Element	
Oxygen	34.96
Nickel	23.35
Carbon	17.43
Sodium	6.77
Sulfur	6.59
Aluminum	4.86
Iron	2.05
Silicon	1.86
Magnesium	1.32
Phosphorus	0.47
Calcium	0.24
Chloride	0.10
Nitrogen	0.00
Fluorine	0.00
Chromium	0.00

TABLE 6: SEM Analysis of the WWFGS Sample

Navajo Waste Stream Characteristics	
Element	Weight Percent
Nickel	32.23
Oxygen	29.53
Carbon	18.65
Iron	9.89
Phosphorus	1.87
Sulfur	1.41
Chromium	1.34
Calcium	1.13
Zinc	0.94
Aluminum	0.73
Copper	0.72
Silicon	0.64
Magnesium	0.45
Sodium	0.31
Chloride	0.15

TABLE 7: SEM Analysis

Sample	SRO Pretest Sample	FGS Pretest Sample	FGS Sample	SRO Sample	WWFGS Sample	25:75 SRO:FGS Sample	50:50 SRO:FGS Sample	75:25 SRO:FGS Sample	25:75 SRO:WWFGS Sample	50:50 SRO:WWFGS Sample	75:25 SRO:WWFGS Sample
Element											
Carbon	2.97	2.47	17.43	9.05	18.65	8.2	8.57	9.4	9.87	10.09	8.96
Nitrogen	0	0	0	0	0	0	2.19	0	0	0	0
Fluorine	0	0	0	0	0	0	0	0	0	0	0
Oxygen	56.91	39.39	34.96	45.52	29.53	46.87	45.91	48.14	42.58	37.5	42.17
Sodium	0	0.54	6.77	0	0.31	0.39	0	1.33	0	0	0.15
Magnesium	2.14	1.91	1.32	4.4	0.45	1.73	1.35	2.97	11.86	8.35	7.39
Aluminum	0	27.94	4.86	0	0.73	0.26	0	1.36	0	0.35	0.68
Silicon	1.92	22	1.86	6.87	0.64	2.17	2.37	3.55	19.27	15.85	13.87
Phosphorus	0	0	0.47	0.2	1.87	0	0	0.16	0	0.32	0.27
Sulfur	13.93	21	6.59	3.72	1.41	0.78	0.67	1.65	0.54	0.73	1.3
Chloride	0	0	0.1	0	0.15	0	0	0	0	0	0.29
Calcium	22.13	0.2	0.24	21.5	1.13	35.11	38.95	23.7	6.95	3.42	7.37
Chromium	0	0	0	0	1.34	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0	0
Titanium	0	0.44	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0	0	0
Iron	0	0.76	2.05	0.51	9.89	0.28	0	0.99	0.51	0.91	1.06
Nickel	0	0	23.35	8.23	32.23	3.14	0	5.76	8.41	22.49	15.45
Copper	0	0	0		0.72	0	0	0	0	0	0
Zinc	0	0	0	0	0.94	0	0	1	0	0	1.05
Strontium	0	0	0	0	0	1.07	0	0	0	0	0
Barium	0	0	0	0	0	0	0	0	0	0	0
Lanthanum	0	2.79	0	0	0	0	0	0	0	0	0
Cerium	0	1.35	0	0	0	0	0	0	0	0	0

TABLE 8: Acid Solubility

Precipitate Sample	Starting Weight	Amount of Acid Added	Final Weight	Acid Solubility
	grams	milliliters	grams	Percent
SRO	0.0481	8	0.0016	96.67
FGS	0.0012	2	0	100
WWFGS	0.0098	8	0	100
75:25 SRO:FGS	0.0014	2	0	100
50:50 SRO:FGS	0.0594	2	0	100
25:75 SRO:FGS	0.0621	2	0	100
75:25 SRO:WWFGS	0.0052	2	0	100
50:50 SRO:WWFGS	0.0082	2	0	100
25:75 SRO:WWFGS	0.0056	2	0	100
SRO Pretest	0.1647	14	0.0377	77.11
FGS Pretest	0.1268	14	0.1148	9.46

ATTACHMENT 1: Intertek Analysis

FLUID / FLUID COMPATIBILITY TESTING

F I N A L R E P O R T

Prepared for

PARSONS BRICKERHOFF

By

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SAMPLE ANALYSIS

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INTRODUCTION

At the request of Parsons Brinckerhoff, high pressure high temperature fluid/fluid compatibility testing was conducted. The solids obtained from the testing were analyzed using Scanning Electron Microcope Energy Dispersive Microchemical Analysis (SEM-EDS) and dissolved in concentrated hydrochloric acid.

EXPERIMENTAL

FLUID/FLUID COMPATIBILITY TESTING

Nine fluid / fluid compatibility tests (100% Secondary Reverse Osmosis (SRO), 100% filtered Flue Gas Scrubber Solution (FGS), 100% Waste Water Flue Gas Scrubber Mixture (WWFGS), 75%:25% Secondary Reverse Osmosis: Flue Gas Scrubber Solution (SRO:FGS), 50%:50% Secondary Reverse Osmosis: Flue Gas Scrubber Solution (SRO:FGS), 25%:75% Secondary Reverse Osmosis: Flue Gas Scrubber Solution (SRO:FGS), 75%:25% Secondary Reverse Osmosis:Waste Water Flue Gas Scrubber Mixture (SRO:WWFGS), 50%:50% Secondary Reverse Osmosis:Waste Water Flue Gas Scrubber Mixture (SRO:WWFGS), and 25%:75% Secondary Reverse Osmosis:Waste Water Flue Gas Scrubber Mixture (SRO:WWFGS) were conducted in one liter stainless steel piston cylinders at 150°F and 5000 psi for twenty days. After twenty days, the cylinders were allowed to cool to room temperature and de-pressurized. After de-pressurization, the cylinders were open one by one and the resulting solutions were filtered to collect the solids which had formed as a result of the testing.

SCANNING ELECTRON MICROSCOPE / ENERGY DISPERSIVE MICROCHEMICAL ANALYSIS (SEM/EDS)

A subsample of each of the samples was transferred from cellulose filter paper to a stub coated with double-faced carbon tape and the sample was then gold-coated. The samples were examined, described and photographed using a Joel scanning electron microscope equiped with an energy-dispersive X-ray analyzer.

HYDROCHLORIC ACID SOLUBILITY TESTING

A known amount of solid from each of the samples was added to 20 milliliter glass vials to which a minimum of 2 milliliters of 12.1 M hydrochloric acid was added. The vials were allowed to set undisturbed for three days. After three days, the samples were photographed and filtered to remove any residual solids. Any residual solids recovered were dried overnight at 105°C, cooled to room temperature and weighed.

RESULTS AND DISCUSSION

The concentrations of the precipitates produced as a results of the liquid / liquid compatibility testing are present in Table 1. The results of the hydrochloric acid solubility testing are presented in Table 2 and Figures 109 - 112. A summary of the SEM-EDS data is presented in Table 3. Photographs of the precipitates, SEM photomicrographs, SEM-EDS data are presented in Figures 1 - 108.

Scanning Electron Microscope photomicrographs of a subsample of the SRO pretest sample are presented in Figures 2 and 7. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 3-6 and Figure 8 and indicate that the sample mainly contains O, Ca, S, C, Mg, and Si which suggests that the sample may contain calcium sulfate, magnesium sulfate, magnesium oxide,and silicon dioxide.

Scanning Electron Microscope photomicrographs of a subsample of the FGS pretest sample are presented in Figures 10 and 17. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 11-16 and Figures 18-22 and indicate that the sample mainly contains O, Al, Si, S, La, C, Mg, Ce, Fe, Na, Ti, and Ca which suggests that the sample may contain aluminium oxide, aluminium sulfate, silicon dixoide, magnesium sulfate, magnesium oxide, lanthanum oxide, cerium oxide, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 100% FGS post test sample are presented in Figures 24 and 29. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 25-28 and Figures 30-32 and indicate that the sample mainly contains O, Ni, C, Na, S, Al, Fe, Si, Mg, P, Ca, and Cl which suggests that the sample may contain nickel oxide, nickel carbonate, aluminium oxide, aluminium sulfate, silicon dioxide, magnesium sulfate, magnesium oxide, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 100% SRO post test sample are presented in Figures 34 and 39. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 35-38 and Figures 40-43 and indicate that the sample mainly contains O, Ca, C, Ni, Si, Mg, S, Fe, and P which suggests that the sample may contain calcium carbonate, calcium sulfate, nickel oxide, nickel carbonate, magnesium sulfate, magnesium oxide, magnesium carbonate, silicon dioxide, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 100% WWFGS post test sample are presented in Figures 45 and 49. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 46-48 and Figures 50-52 and indicate that the sample mainly contains Ni, O, C, Fe, P, S, Cr, Ca, Zn, Al, Cu, Si, Mg, and Na which suggests that the sample may contain nickel carbonate, nickel oxide, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 25%:75% SRO:FGS post test sample are presented in Figures 54 and 57. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 55-56 and Figures 58-61 and indicate that the sample mainly contains O, Ca, C, Ni, Si, Mg, Sr, S, Na, Fe, and Al which suggests that the sample may contain calcium carbonate, calcium sulfate, strontium carbonate, strontium sulfate, silicon dioxide, magnesium oxide, nickel carbonate, and nickel oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 50%:50% SRO:FGS post test sample are presented in Figures 63 and 67. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 64-66 and Figures 68-71 and indicate that the sample mainly contains O, Ca, C, Si, N, and S which suggests that the sample may contain calcium carbonate, calcium sulfate, silicon dioxide, and magnesium oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 75%:25% SRO:FGS post test sample are presented in Figures 73 and 77. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 74-76 and Figures 78-82 and indicate that the sample mainly contains O, Ca, C, Ni, Si, Mg, S, Al, Na, Zn, Fe, and P which suggests that the sample may contain calcium carbonate, calcium sulfate, nickel carbonate, nickel oxide, silicon dioxide, zinc oxide, iron oxide, and magnesium oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 25%:75% SRO:WWFGS post test sample are presented in Figures 84 and 88. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 85-87 and Figures 89-90 and indicate that the sample mainly contains O, Si, Mg, C, Ni, Ca, S, and Fe which suggests that the sample may contain silicon dioxide, nickel carbonate, nickel oxide, magnesium carbonate, magnesium oxide, calcium carbonate, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 50%:50% SRO:WWFGS post test sample are presented in Figures 92 and 96. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 93-95 and Figures 97-99 and indicate that the sample mainly contains O, Ni, Si, C, Mg, Ca, Fe, S, Al, and P which suggests that the sample may contain silicon dioxide, nickel carbonate, nickel oxide, magnesium carbonate, magnesium oxide, calcium carbonate, and iron oxide.

Scanning Electron Microscope photomicrographs of a subsample of the 75%:25% SRO:WWFGS post test sample are presented in Figures 101 and 105. The EDS micro-chemical analysis of the selected parts of the subsample are presented in Figures 102-104 and Figures 106-108 and indicate that the sample mainly contains O, Ni, Si, C, Mg, Ca, S, Fe, Zn, Cl, P, and Na which suggests that the sample may contain silicon dioxide, nickel carbonate, nickel oxide, magnesium carbonate, magnesium oxide, calcium carbonate, iron oxide, and zinc oxide.

TABLE 1

CONCENTRATIONS OF PRECIPITATE PRODUCED AS A RESULT OF THE TWENTY DAY FLUID / FLUID COMPATIBILITY TESTING

Test Sample	Concentration of Precipitate Produced
SRO	0.6217 grams/liter
FGS	0.3750 grams/liter
WWFGS	0.5267 grams/liter
75:25 SRO:FGS	0.8033 grams/liter
50:50 SRO:FGS	0.9083 grams/liter
25:75 SRO:FGS	0.4050 grams/liter
75:25 SRO:WWFGS	0.4667 grams/liter
50:50 SRO:WWFGS	0.4050 grams/liter
25:75 SRO:WWFGS	0.4450 grams/liter
FGS Pretest	0.9700 grams/liter

TABLE 2

RESULTS OF THE ACID SOLUBILITY TESTING OF THE PRODUCED PRECIPITATES WITH 12.1 M HYDROCHLORIC ACID

Precipitate Sample	Starting Weight	Amout of Acid Added	Final Weight	Acid Solubility
	grams	milliliters	grams	Percent
SRO	0.0481	8	0.0016	96.67
FGS	0.0012	2	0	100
WWFGS	0.0098	8	0	100
75:25 SRO:FGS	0.0014	2	0	100
50:50 SRO:FGS	0.0594	2	0	100
25:75 SRO:FGS	0.0621	2	0	100
75:25 SRO:WWFGS	0.0052	2	0	100
50:50 SRO:WWFGS	0.0082	2	0	100
25:75 SRO:WWFGS	0.0056	2	0	100
SRO Pretest	0.1647	14	0.0377	77.11
FGS Pretest	0.1268	14	0.1148	9.46

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TABLE 3
SUMMARY OF THE SCANNING ELECTRON MICROSCOPE ENERGY DISPERSIVE MICROCHEMICAL ANALYSIS OF SUBSAMPLES OF THE PRODUCED SOLIDS

Sample		SRO Pretest Sample	FGS Pretest Sample	FGS Sample	SRO Sample	WWFGS Sample	25:75 SRO:FGS Sample	50:50 SRO:FGS Sample	75:25 SRO:FGS Sample	25:75 SRO:WWFGS Sample	50:50 SRO:WWFGS Sample	75:25 SRO:WWFGS Sample
Element	**Unit**											
Carbon	**weight percent**	2.97	2.47	17.43	9.05	18.65	8.20	8.57	9.40	9.87	10.09	8.96
Nitrogen	**weight percent**	0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.00	0.00	0.00	0.00
Fluorine	**weight percent**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen	**weight percent**	56.91	39.39	34.96	45.52	29.53	46.87	45.91	48.14	42.58	37.50	42.17
Sodium	**weight percent**	0.00	0.54	6.77	0.00	0.31	0.39	0.00	1.33	0.00	0.00	0.15
Magnesium	**weight percent**	2.14	1.91	1.32	4.40	0.45	1.73	1.35	2.97	11.86	8.35	7.39
Aluminium	**weight percent**	0.00	27.94	4.86	0.00	0.73	0.26	0.00	1.36	0.00	0.35	0.68
Silicon	**weight percent**	1.92	22.00	1.86	6.87	0.64	2.17	2.37	3.55	19.27	15.85	13.87
Phosphorus	**weight percent**	0.00	0.00	0.47	0.20	1.87	0.00	0.00	0.16	0.00	0.32	0.27
Sulfur	**weight percent**	13.93	21.00	6.59	3.72	1.41	0.78	0.67	1.65	0.54	0.73	1.30
Chloride	**weight percent**	0.00	0.00	0.10	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.29
Calcium	**weight percent**	22.13	0.20	0.24	21.50	1.13	35.11	38.95	23.70	6.95	3.42	7.37
Chromium	**weight percent**	0.00	0.00	0.00	0.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00
Manganese	**weight percent**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Titanium	**weight percent**	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanadium	**weight percent**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron	**weight percent**	0.00	0.76	2.05	0.51	9.89	0.28	0.00	0.99	0.51	0.91	1.06
Nickel	**weight percent**	0.00	0.00	23.35	8.23	32.23	3.14	0.00	5.76	8.41	22.49	15.45
Copper	**weight percent**	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	**weight percent**	0.00	0.00	0.00	0.00	0.94	0.00	0.00	1.00	0.00	0.00	1.05
Strontium	**weight percent**	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00
Barium	**weight percent**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lanthanum	**weight percent**	0.00	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cerium	**weight percent**	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE 1
PHOTOGRAPH OF THE SRO PRETEST SAMPLE

FIGURE 2
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE SRO PRETEST SAMPLE

FIGURE 3
EDS MICROCHEMICAL ANALYSIS OF THE SRO PRETEST SAMPLE PARTICLES SHOWN IN FIGURE 2

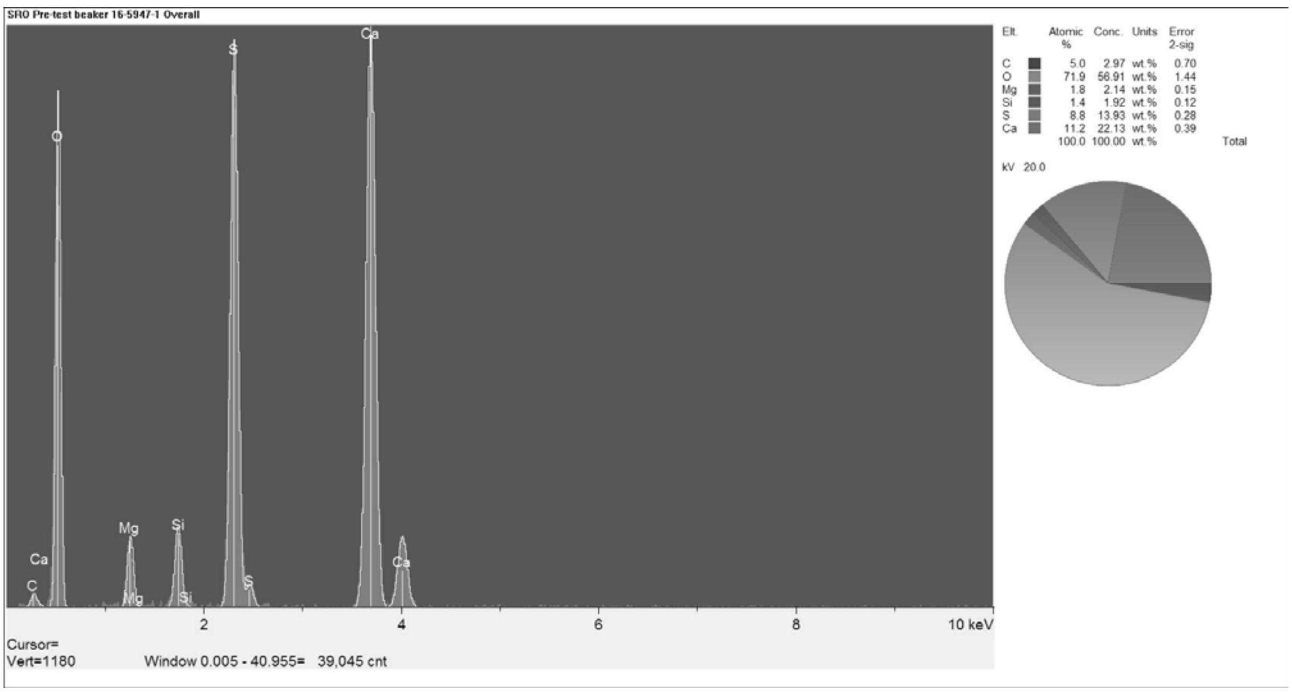

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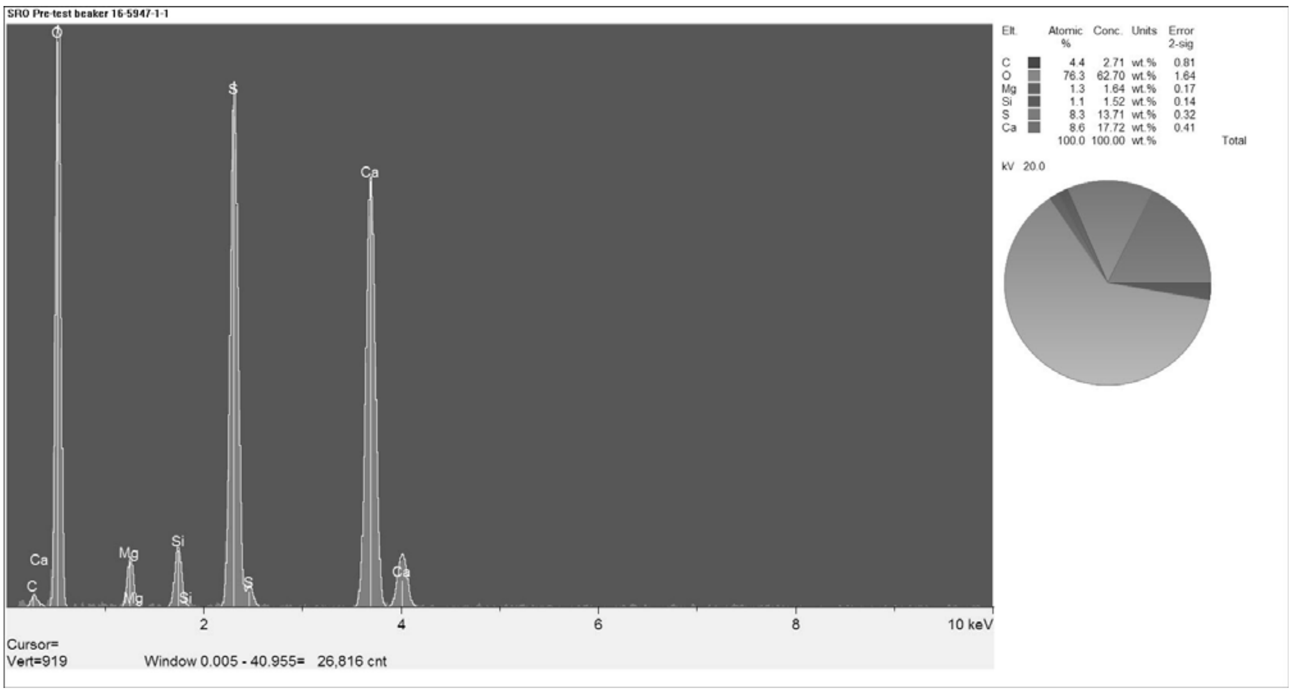
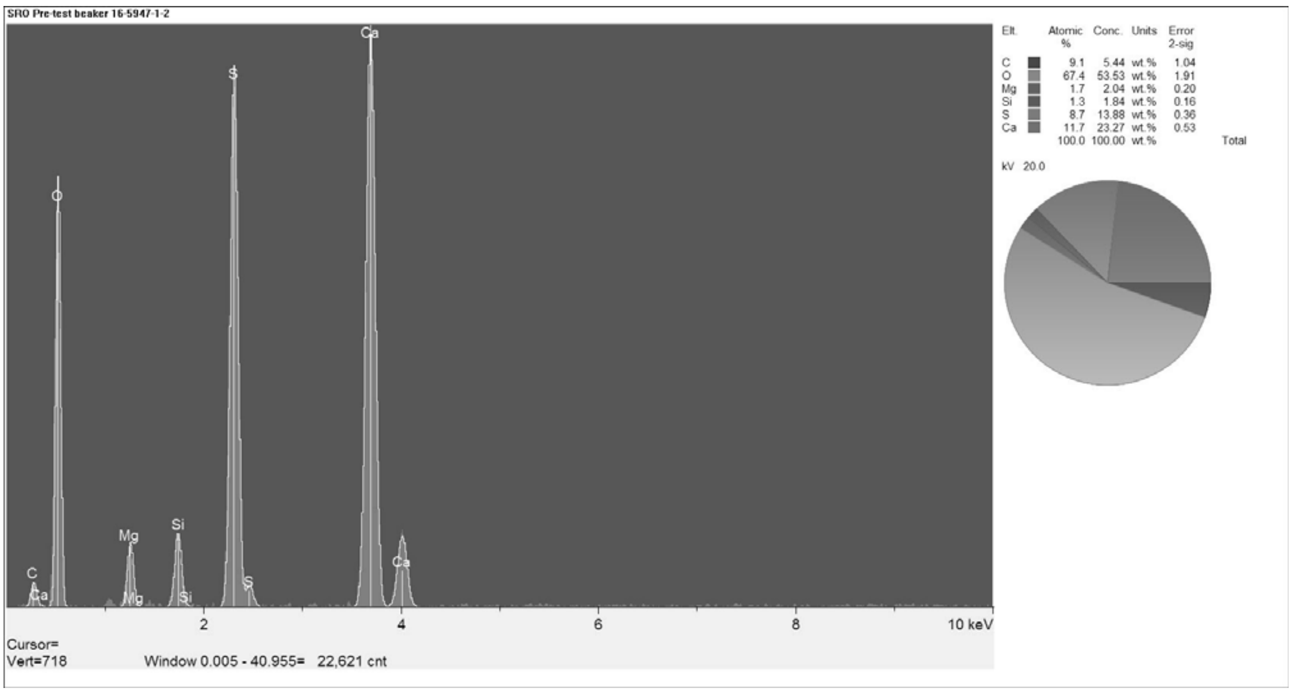
FIGURE 4
EDS MICROCHEMICAL ANALYSIS OF THE SRO PRETEST SAMPLE PARTICLES LABELED #1 IN FIGURE 2



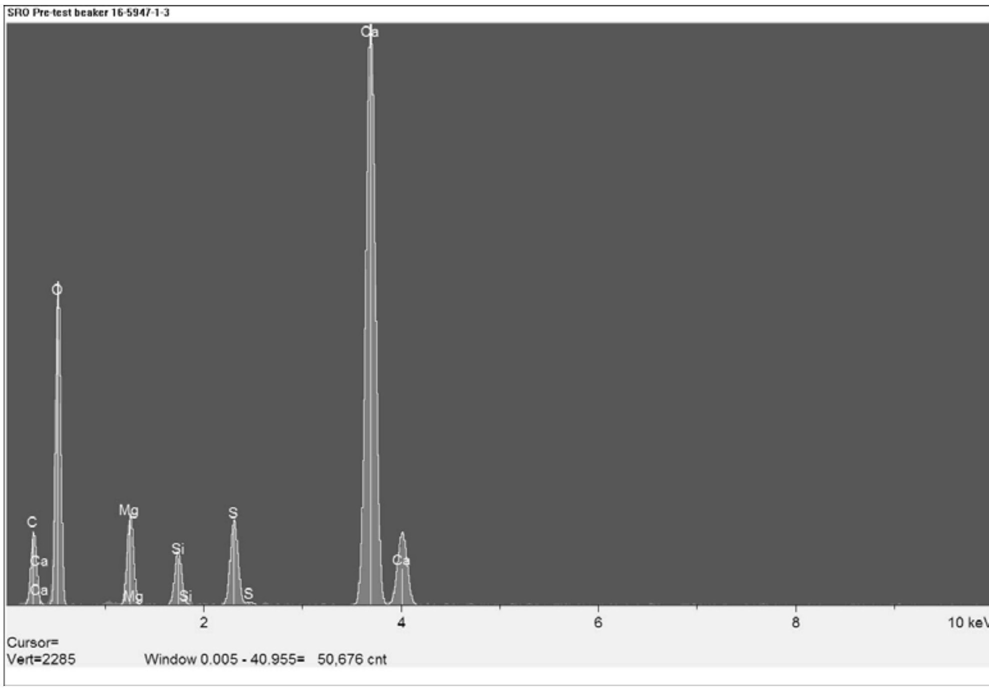
Elt.	Atomic %	Conc.	Units	Error 2-sig	
C	4.4	2.71	wt.%	0.81	
O	76.3	62.70	wt.%	1.64	
Mg	1.3	1.64	wt.%	0.17	
Si	1.1	1.52	wt.%	0.14	
S	8.3	13.71	wt.%	0.32	
Ca	8.6	17.72	wt.%	0.41	
	100.0	100.00	wt.%		Total

FIGURE 5
EDS MICROCHEMICAL ANALYSIS OF THE SRO PRETEST SAMPLE PARTICLES LABELED #2 IN FIGURE 2



Elt.	Atomic %	Conc.	Units	Error 2-sig	
C	9.1	5.44	wt.%	1.04	
O	67.4	53.53	wt.%	1.91	
Mg	1.7	2.04	wt.%	0.20	
Si	1.3	1.84	wt.%	0.16	
S	8.7	13.88	wt.%	0.36	
Ca	11.7	23.27	wt.%	0.53	
	100.0	100.00	wt.%		Total

FIGURE 6
EDS MICROCHEMICAL ANALYSIS OF THE SRO PRETEST SAMPLE PARTICLES LABELED #3 IN FIGURE 2



Elt.	Atomic %	Conc.	Units	Error 2-sig	
C	16.2	10.11	wt.%	0.50	
O	64.4	53.44	wt.%	1.23	
Mg	2.9	3.60	wt.%	0.16	
Si	1.2	1.72	wt.%	0.10	
S	1.6	2.72	wt.%	0.11	
Ca	13.7	28.41	wt.%	0.36	
	100.0	100.00	wt.%		Total

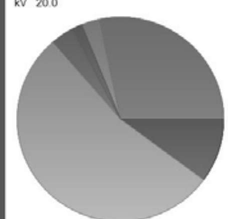


FIGURE 7
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE SRO PRETEST SAMPLE

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FIGURE 8
EDS MICROCHEMICAL ANALYSIS OF THE SRO PRETEST SAMPLE PARTICLES LABELED #1 IN FIGURE 7

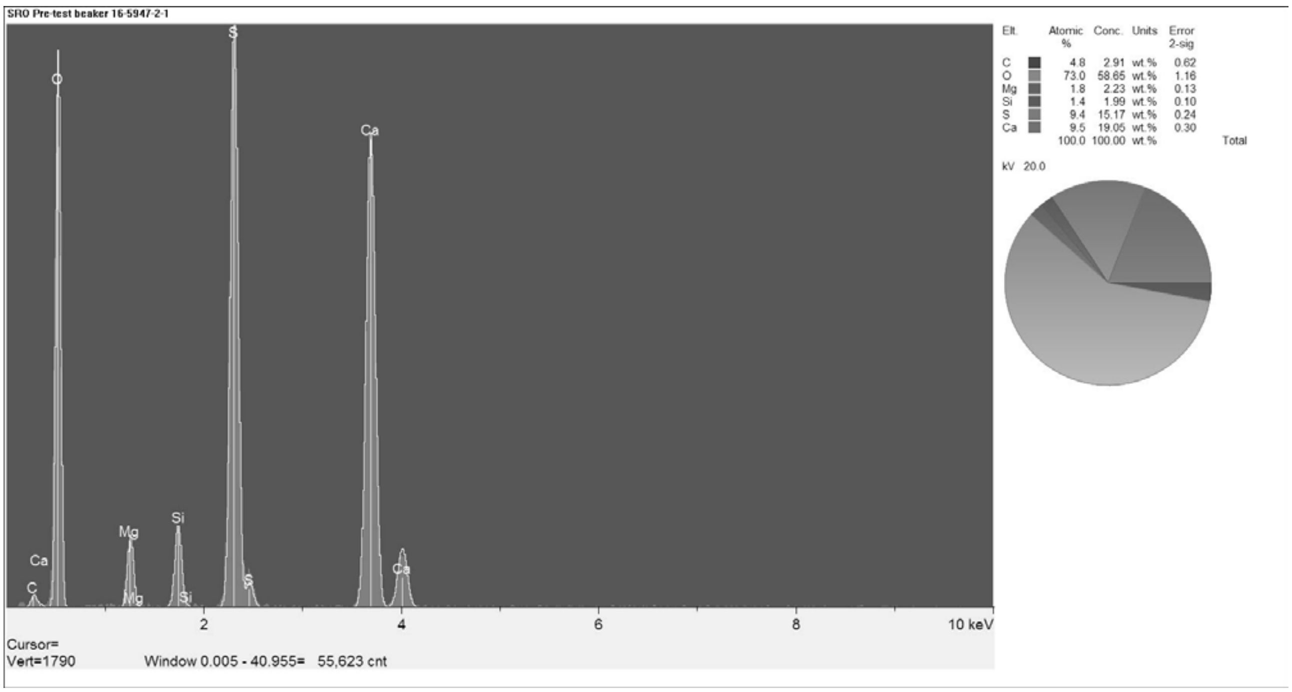

FIGURE 9
PHOTOGRAPH OF THE FGS PRETEST SAMPLE

FIGURE 10
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE FGS PRETEST SAMPLE

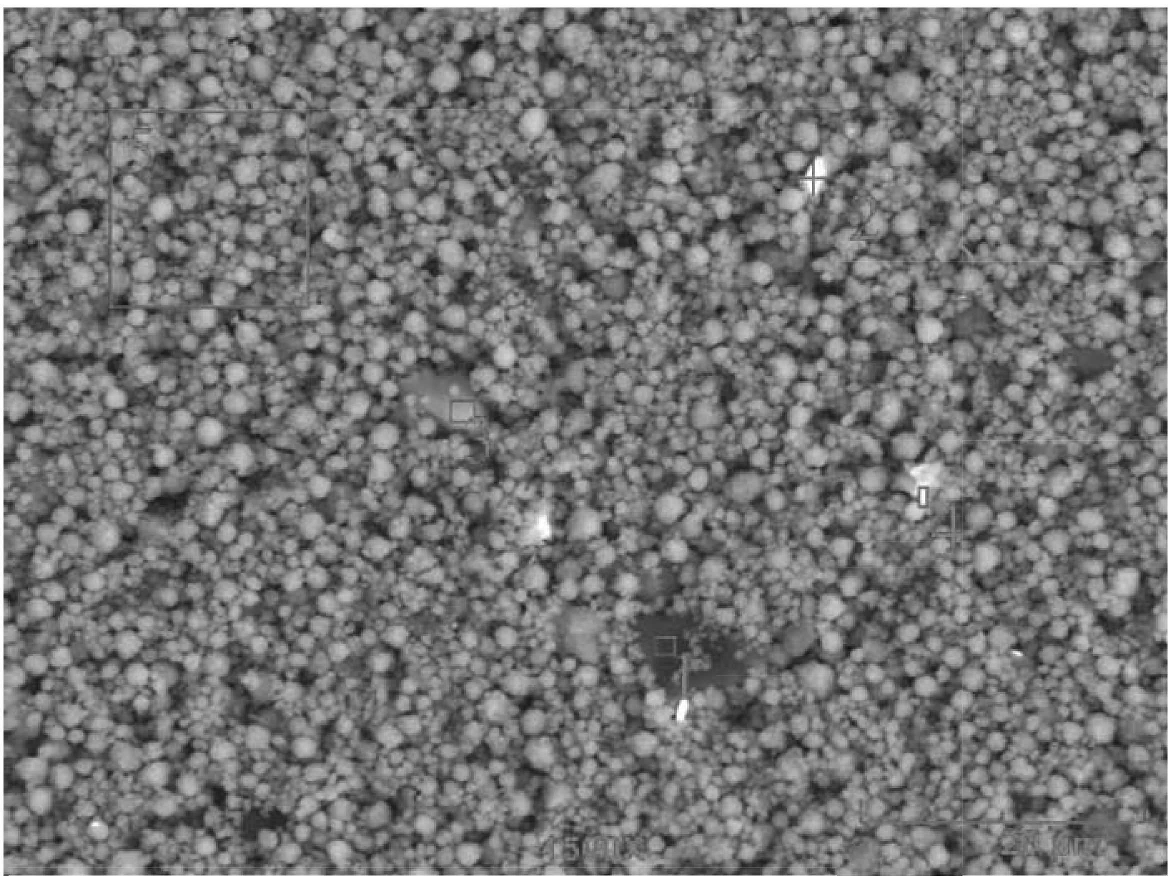

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FIGURE 11
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES SHOWN IN FIGURE 10

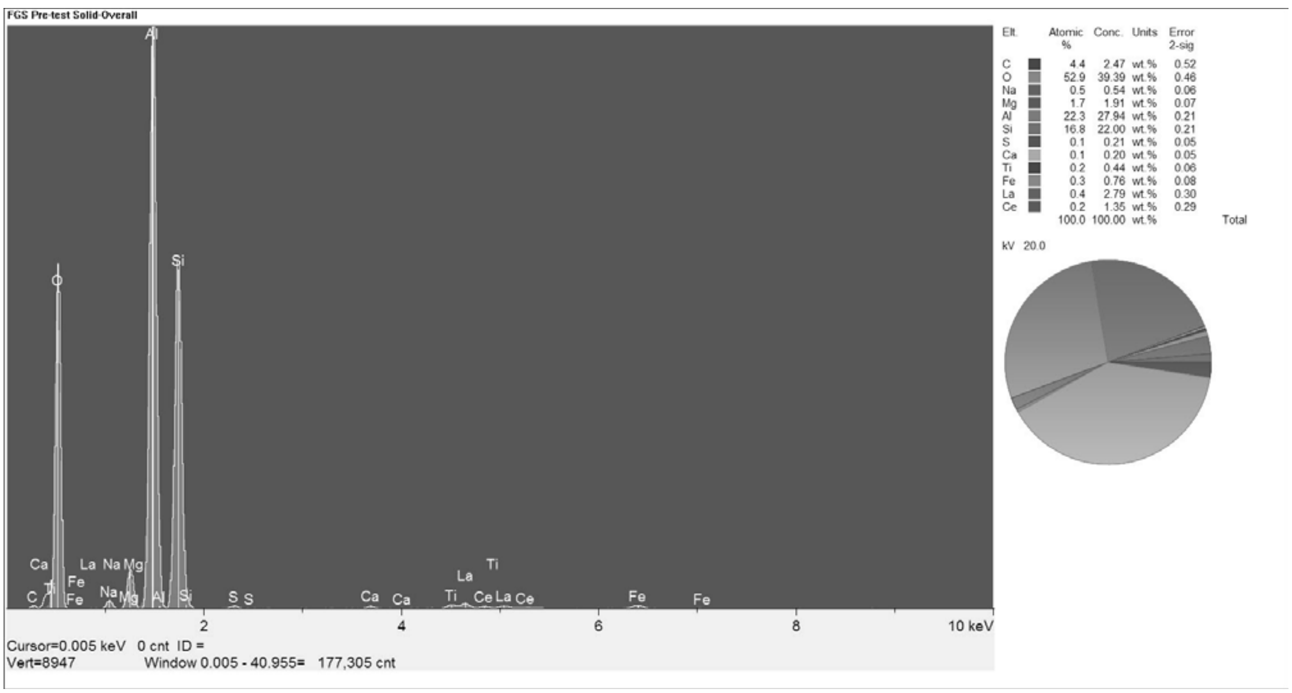

FIGURE 12
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #1 IN FIGURE 10

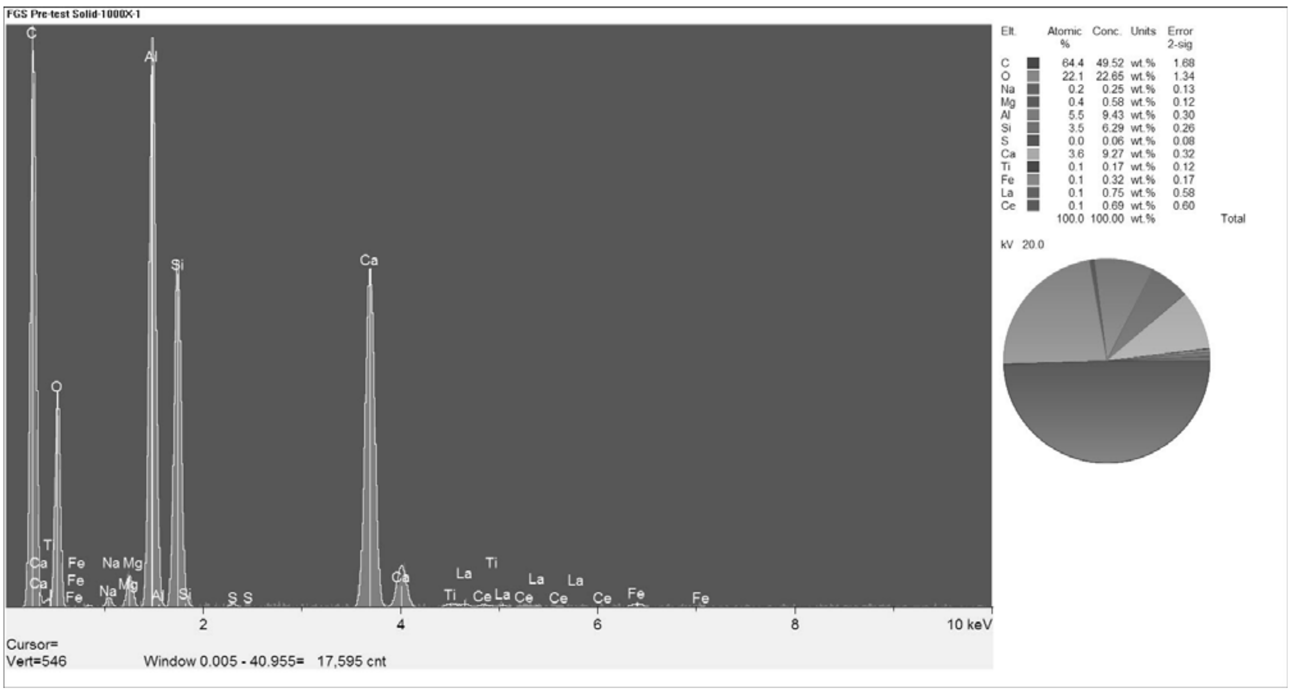

FIGURE 13
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #2 IN FIGURE 10

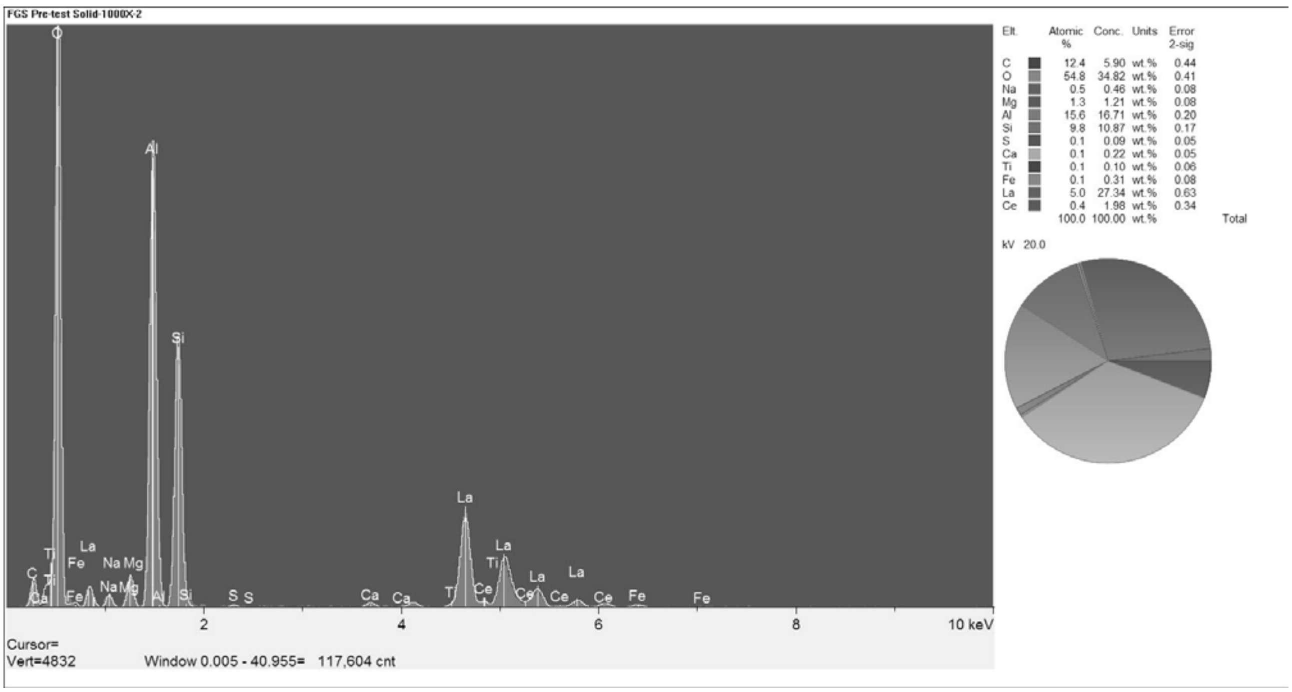

FIGURE 14
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #3 IN FIGURE 10

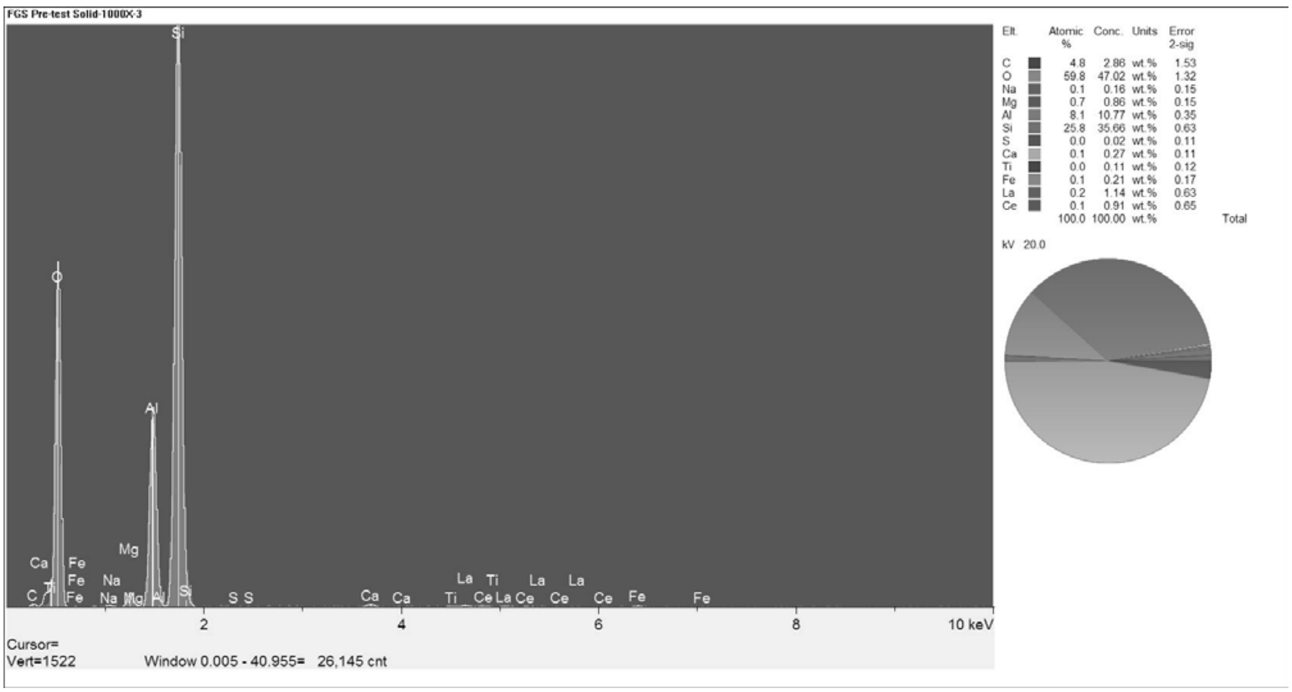

FIGURE 15
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #4 IN FIGURE 10

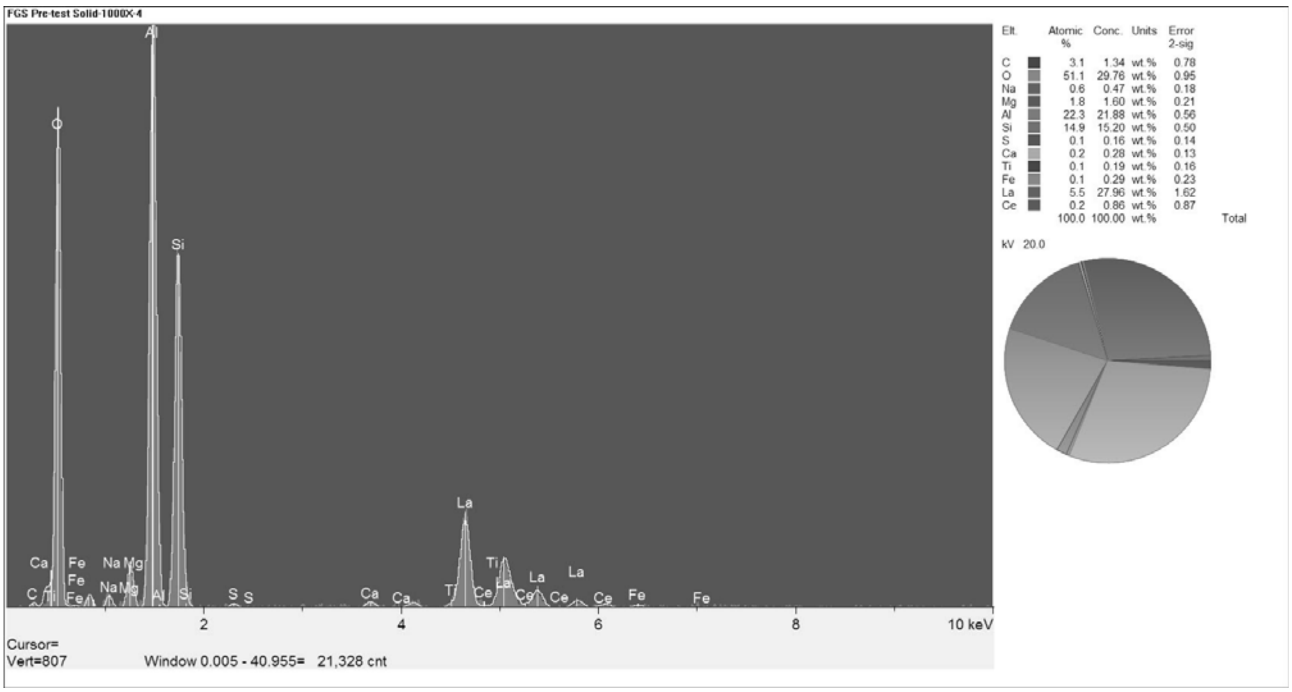

FIGURE 16
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #5 IN FIGURE 10

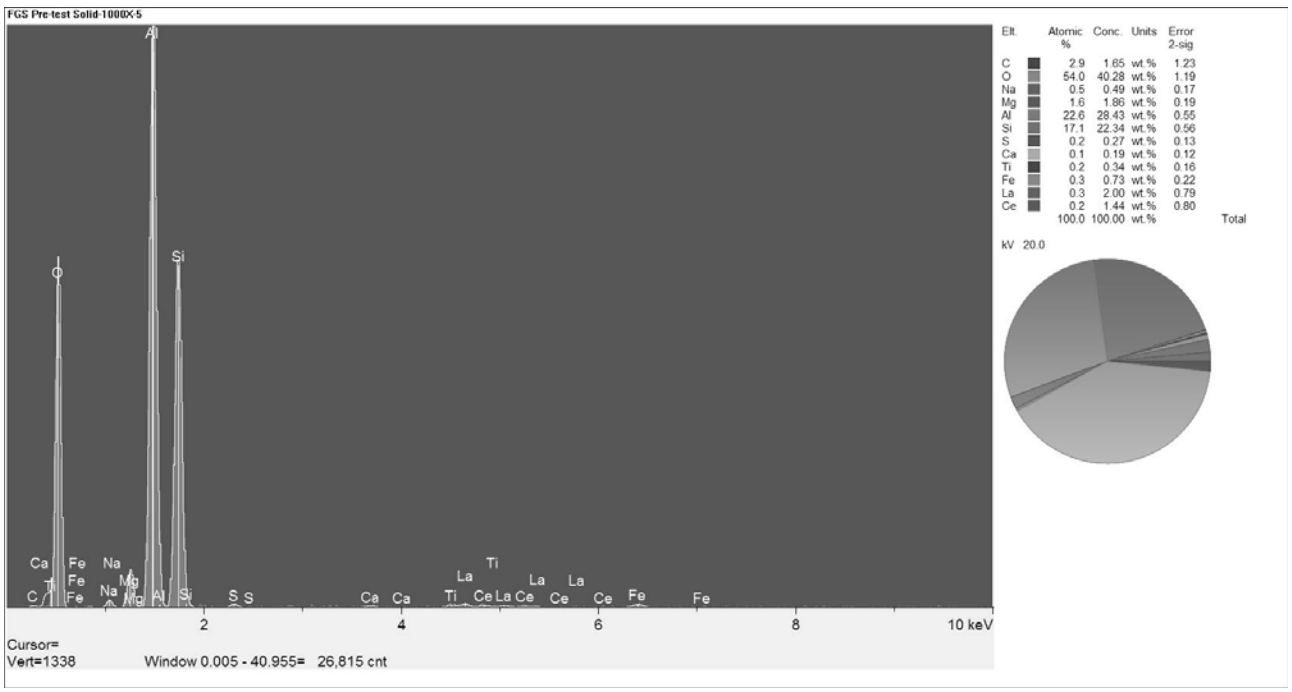

FIGURE 17
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE FGS PRETEST SAMPLE

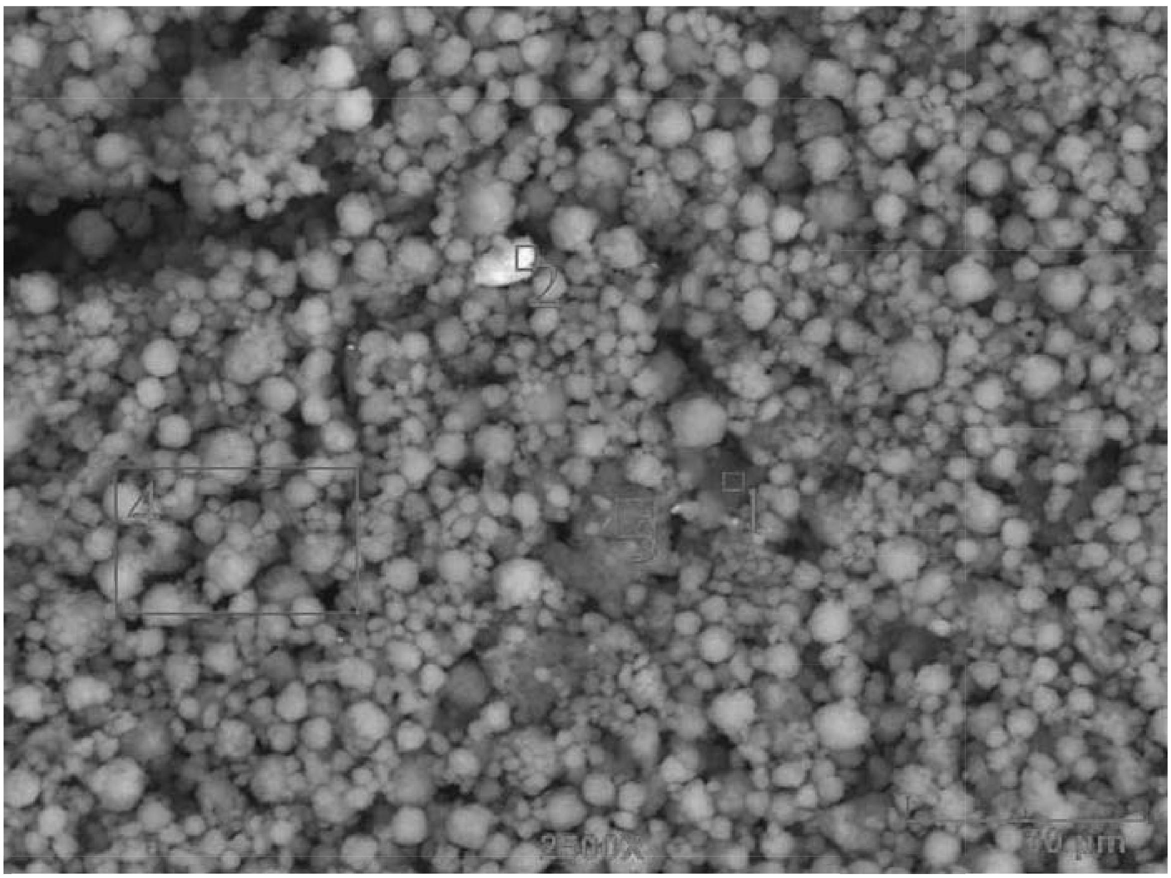

FIGURE 18
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES SHOWN IN FIGURE 17

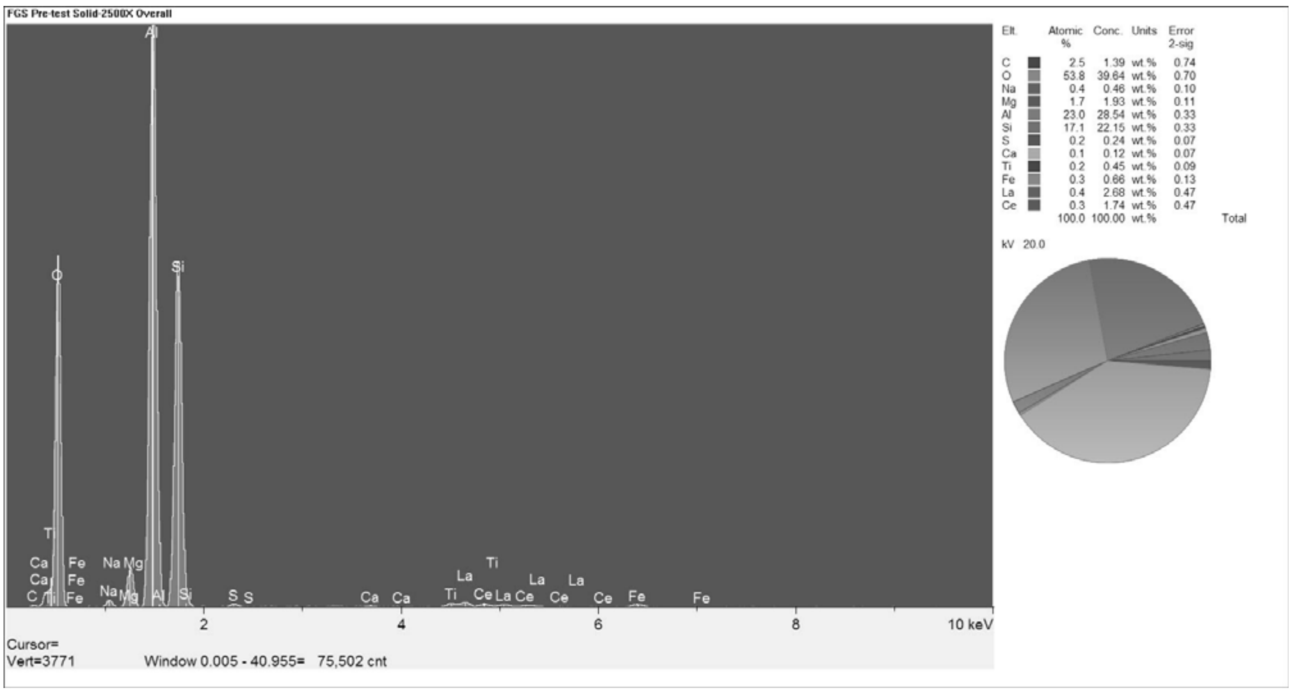

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FIGURE 19
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #1 IN FIGURE 17

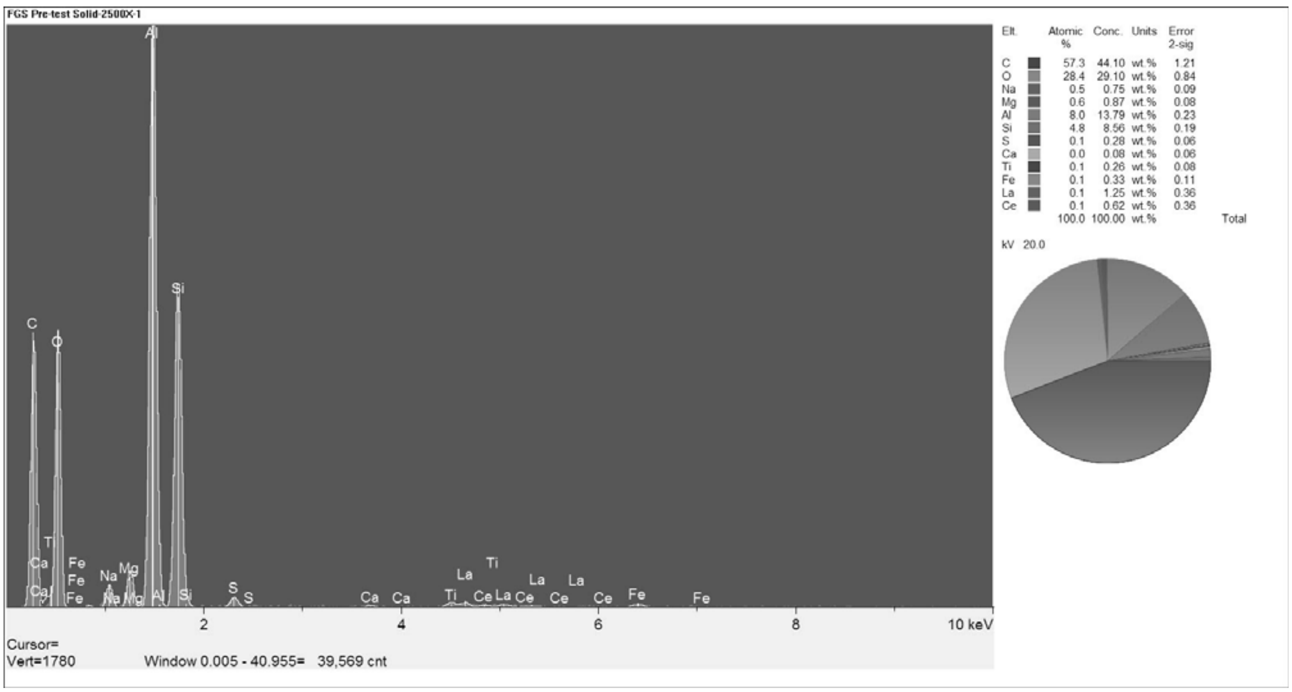
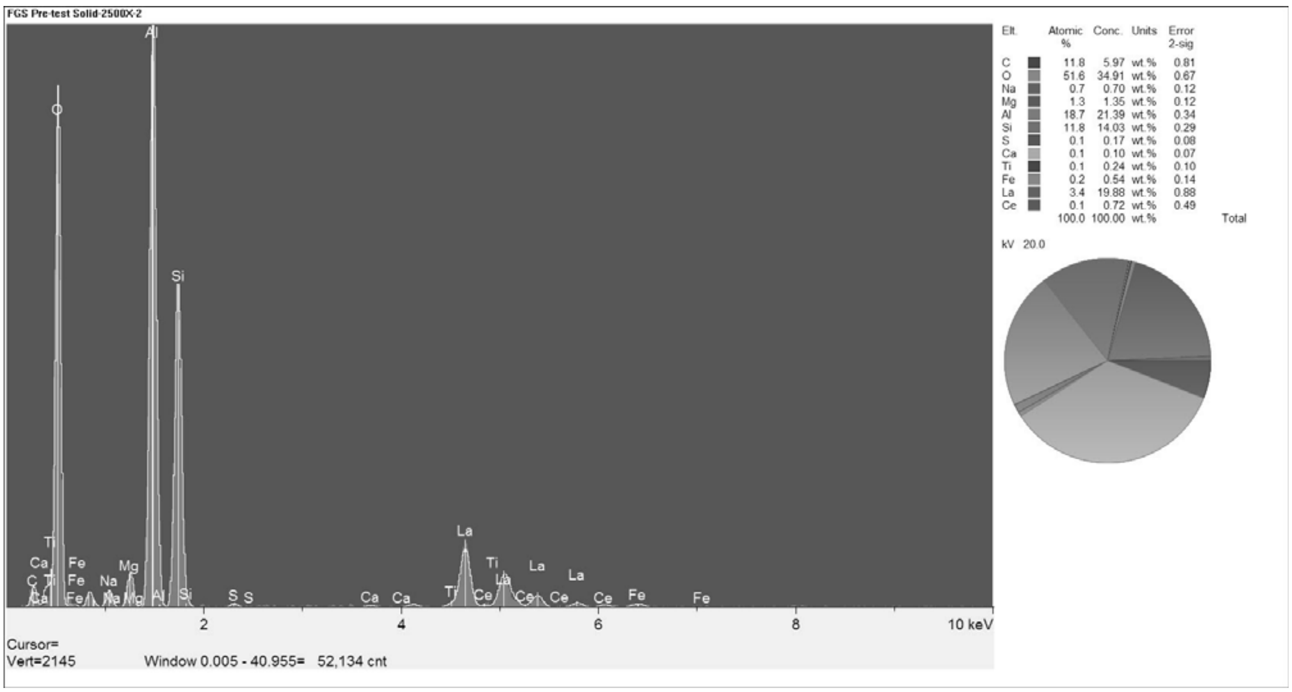


FIGURE 20
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #2 IN FIGURE 17



Elt.	Atomic %	Conc.	Units	Error 2-sig
C	11.8	5.97	wt.%	0.81
O	51.6	34.91	wt.%	0.67
Na	0.7	0.70	wt.%	0.12
Mg	1.3	1.35	wt.%	0.12
Al	18.7	21.39	wt.%	0.34
Si	11.8	14.03	wt.%	0.29
S	0.1	0.17	wt.%	0.08
Ca	0.1	0.10	wt.%	0.07
Ti	0.1	0.24	wt.%	0.10
Fe	0.2	0.54	wt.%	0.14
La	3.4	19.88	wt.%	0.88
Ce	0.1	0.72	wt.%	0.49
	100.0	100.00	wt.%	Total

FIGURE 21
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #3 IN FIGURE 17

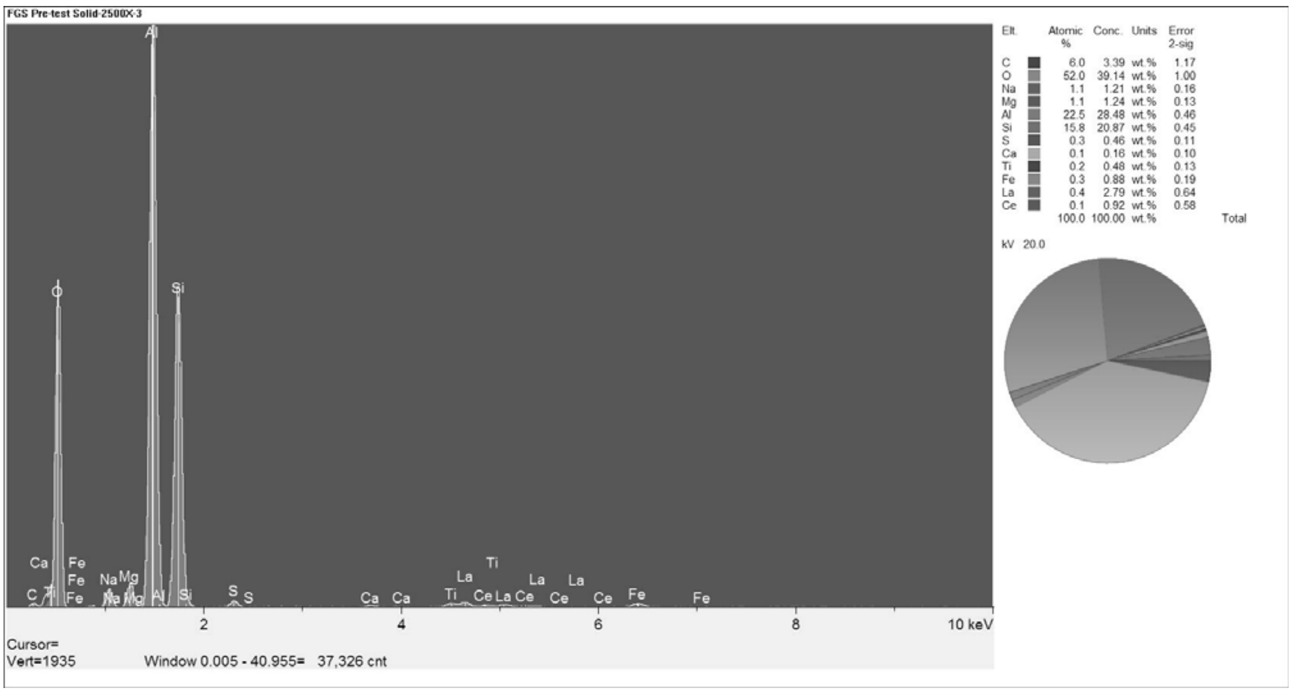


FIGURE 22
EDS MICROCHEMICAL ANALYSIS OF THE FGS PRETEST SAMPLE PARTICLES LABELED #4 IN FIGURE 17

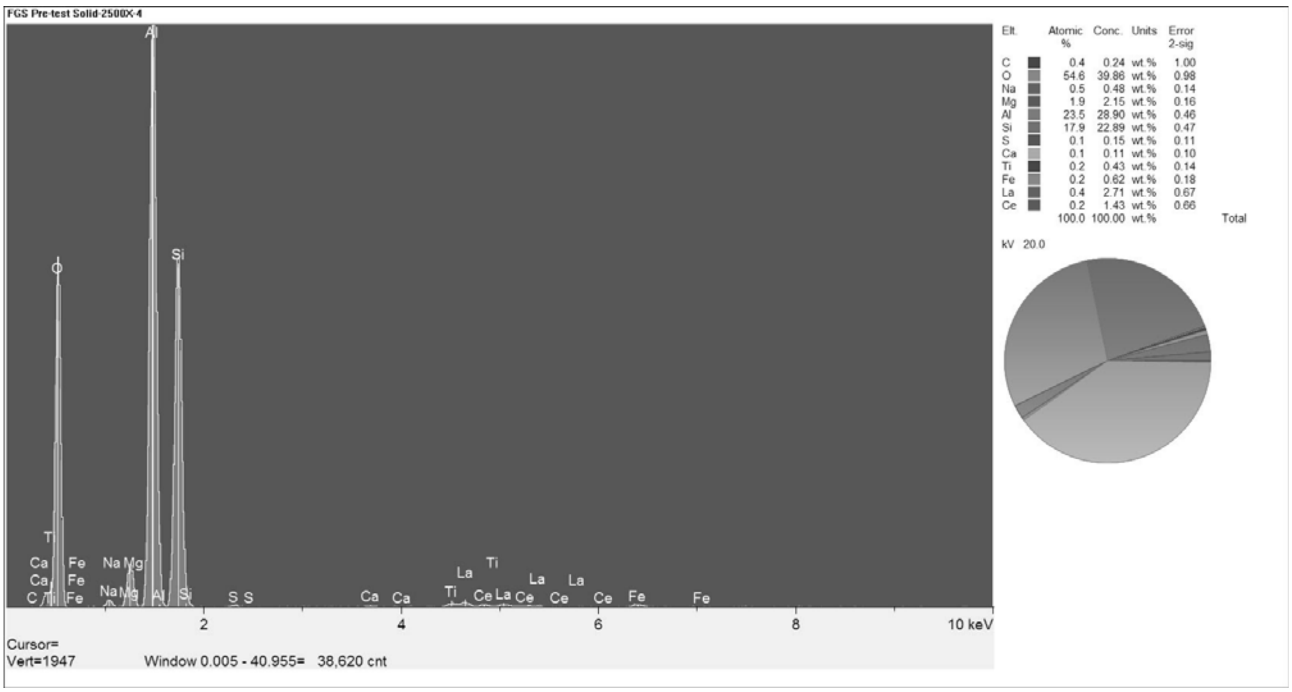


FIGURE 23
PHOTOGRAPH OF THE FGS SAMPLE PRECIPITATE

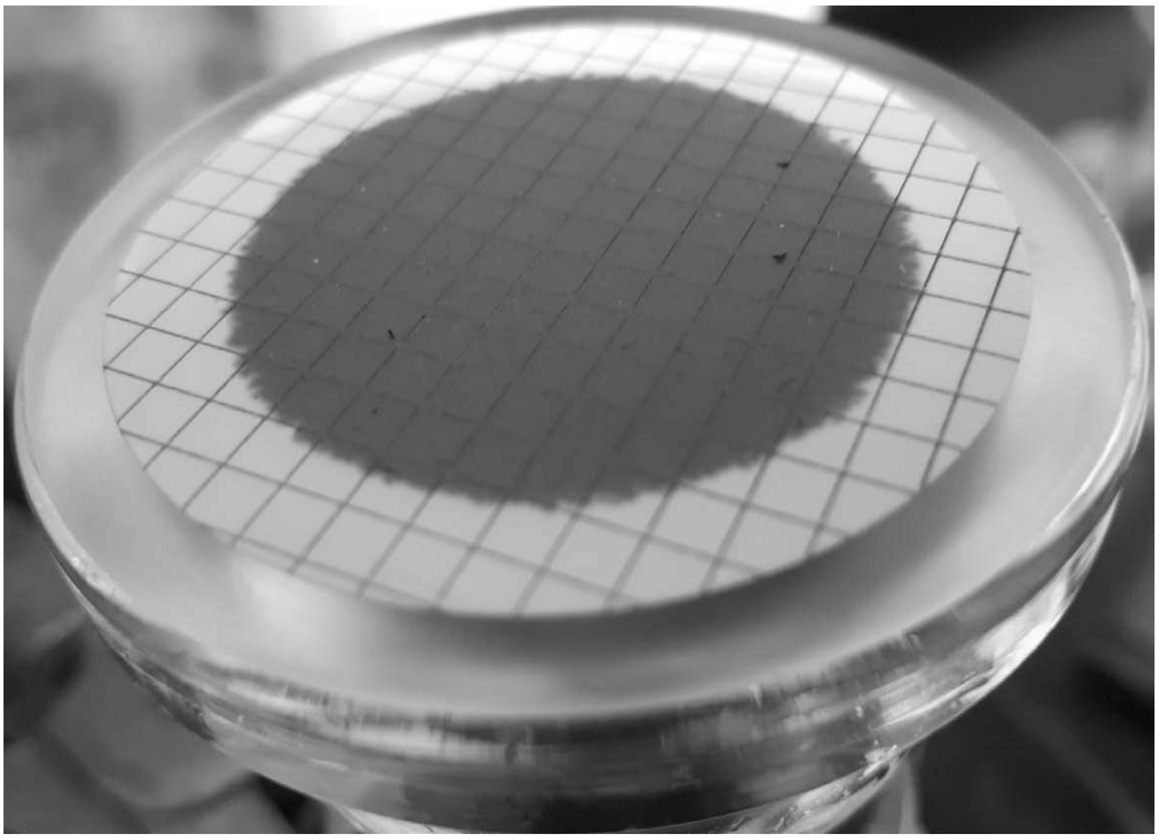


FIGURE 24
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE FGS SAMPLE PRECIPITATE

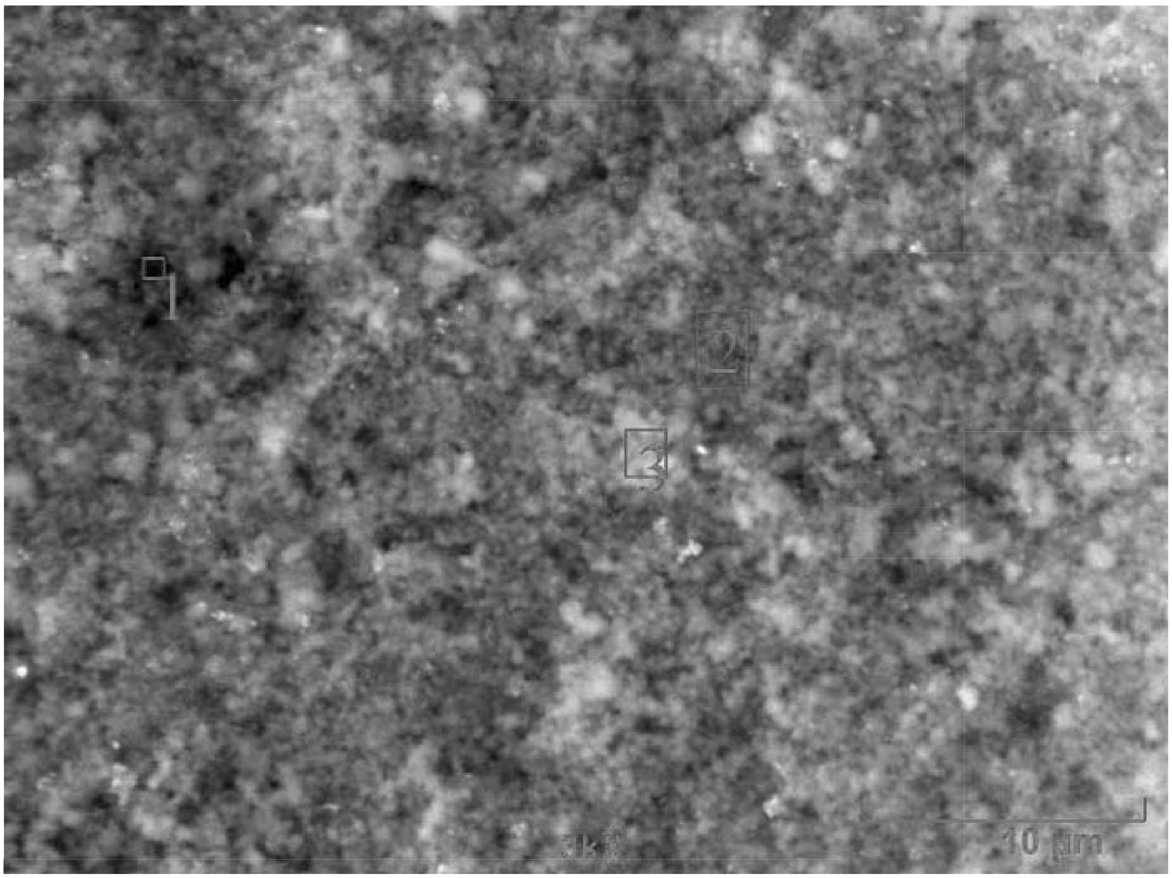


FIGURE 25
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 24

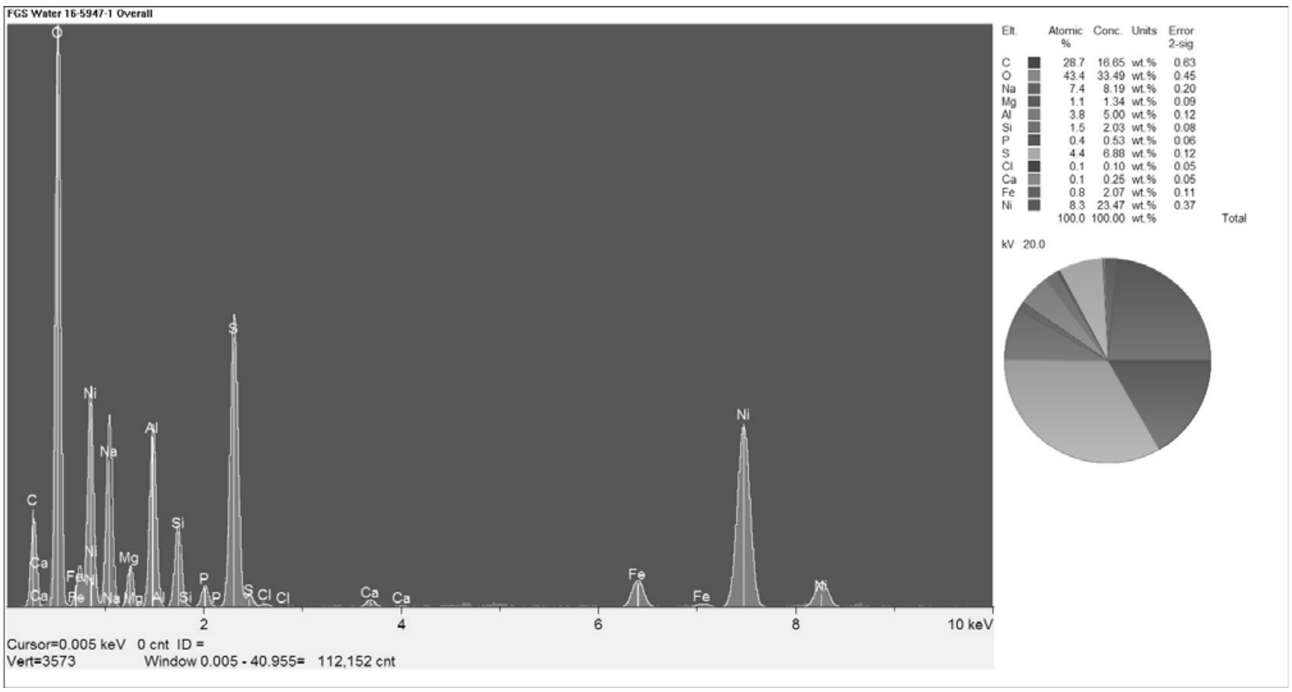


FIGURE 26
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 24

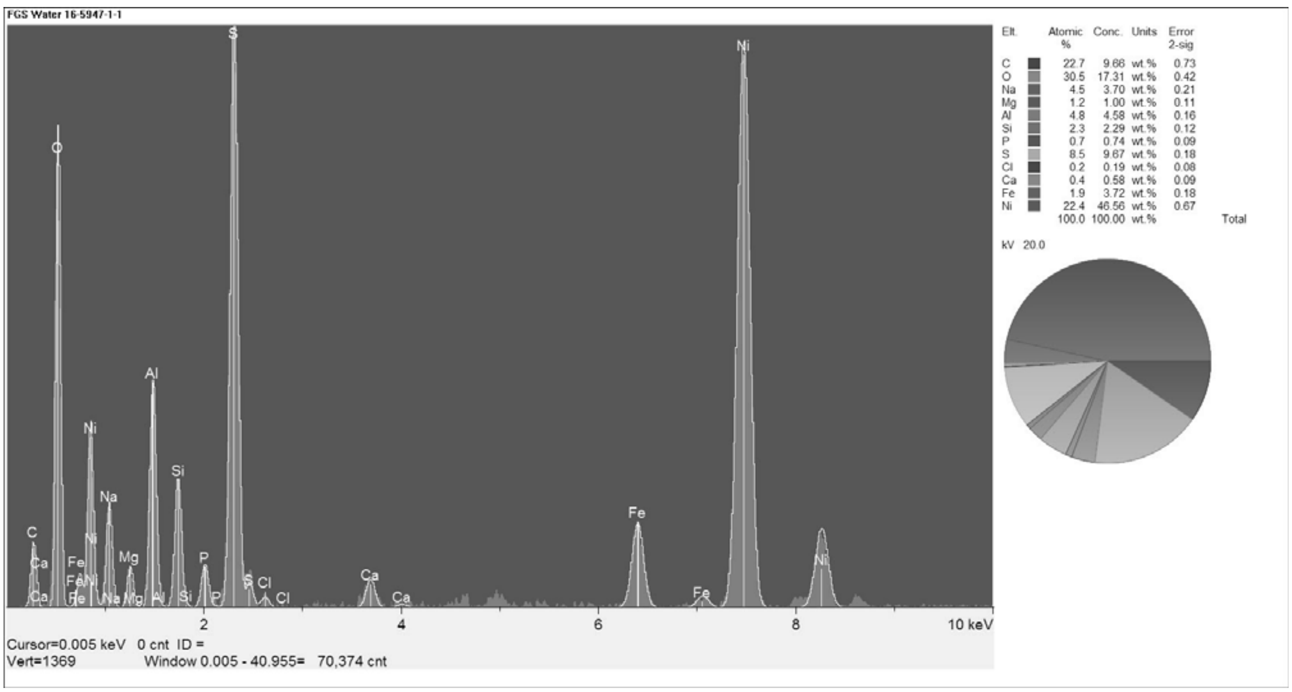


FIGURE 27
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 24

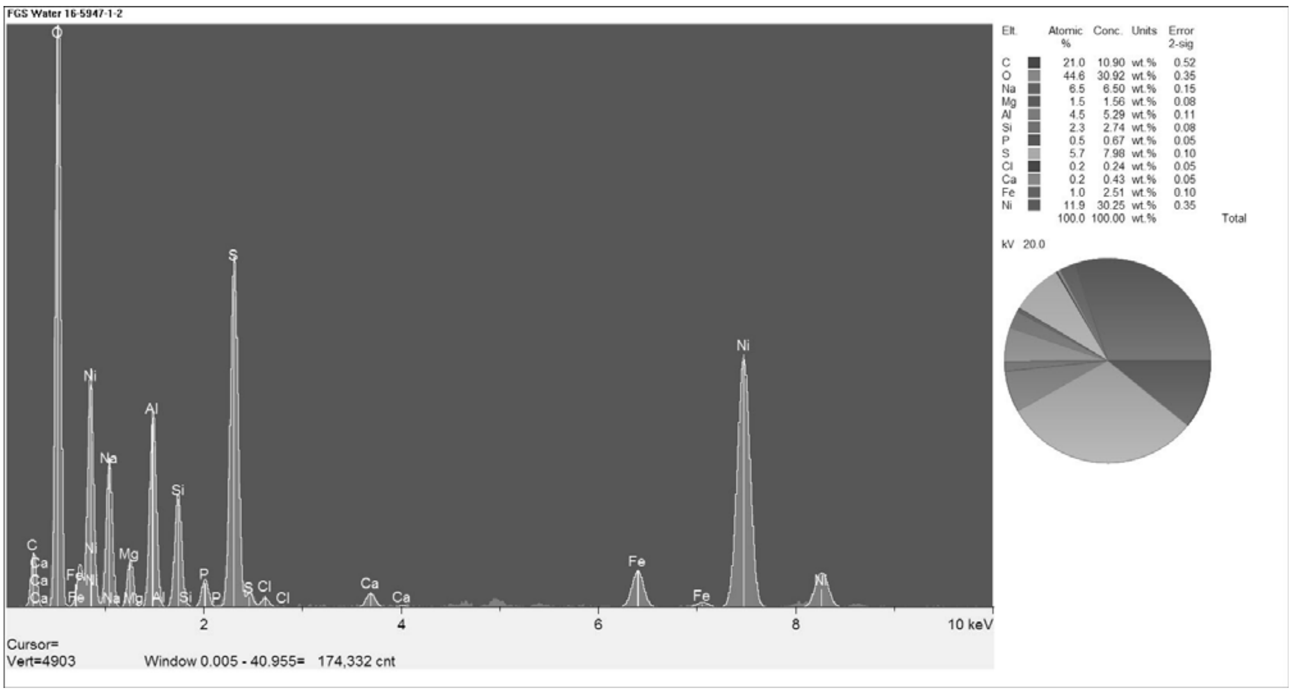


FIGURE 28
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES LABELED #3 IN FIGURE 24

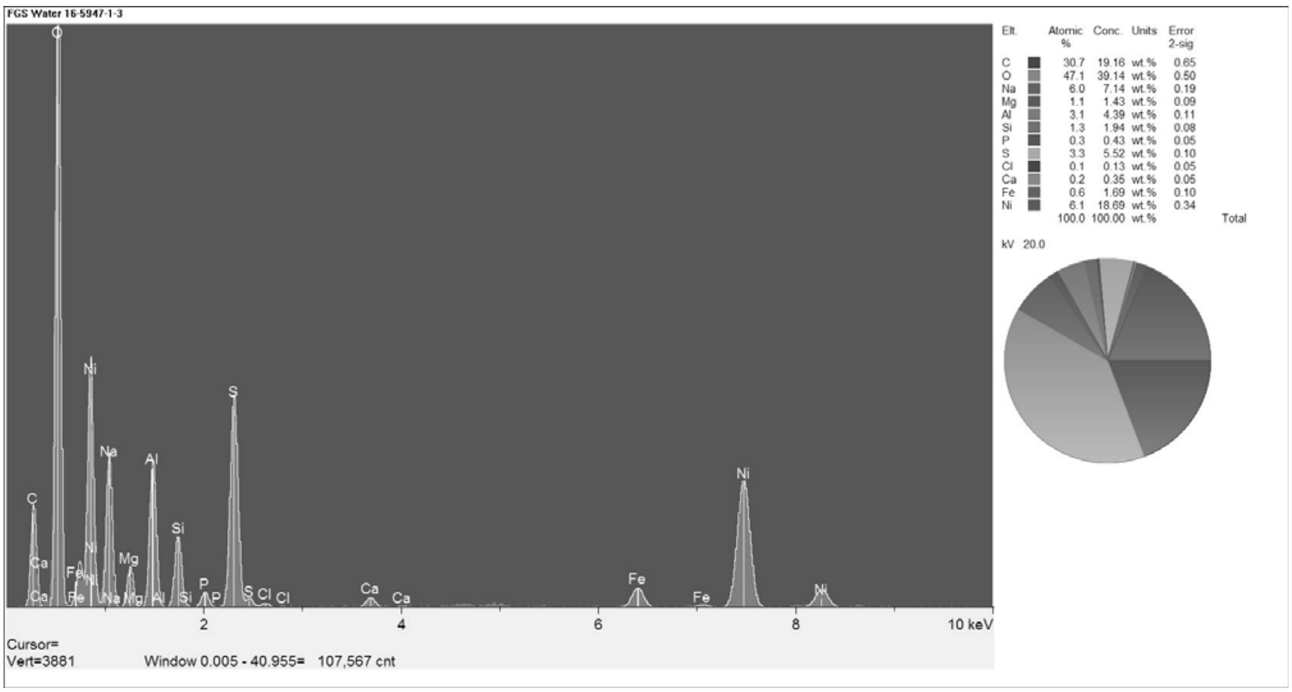


FIGURE 29
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE FGS SAMPLE PRECIPITATE

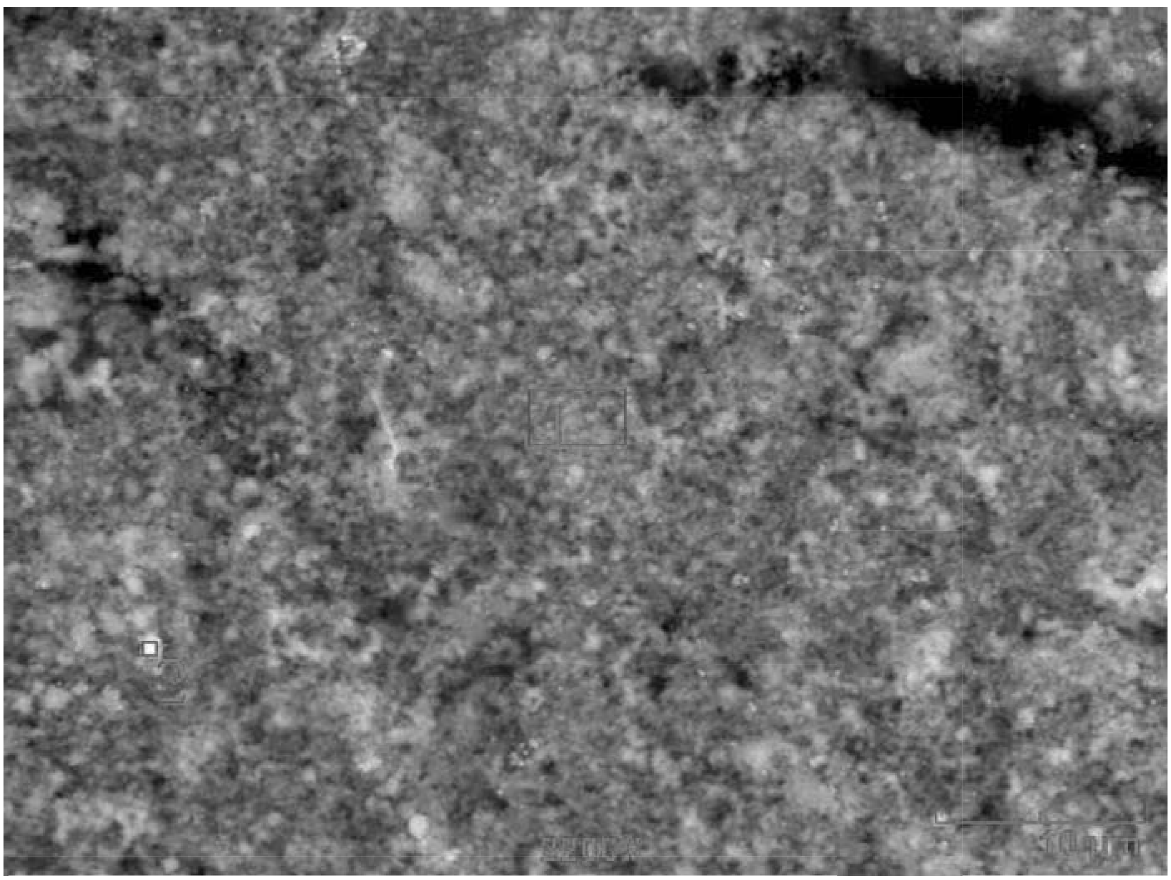


FIGURE 30
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 29

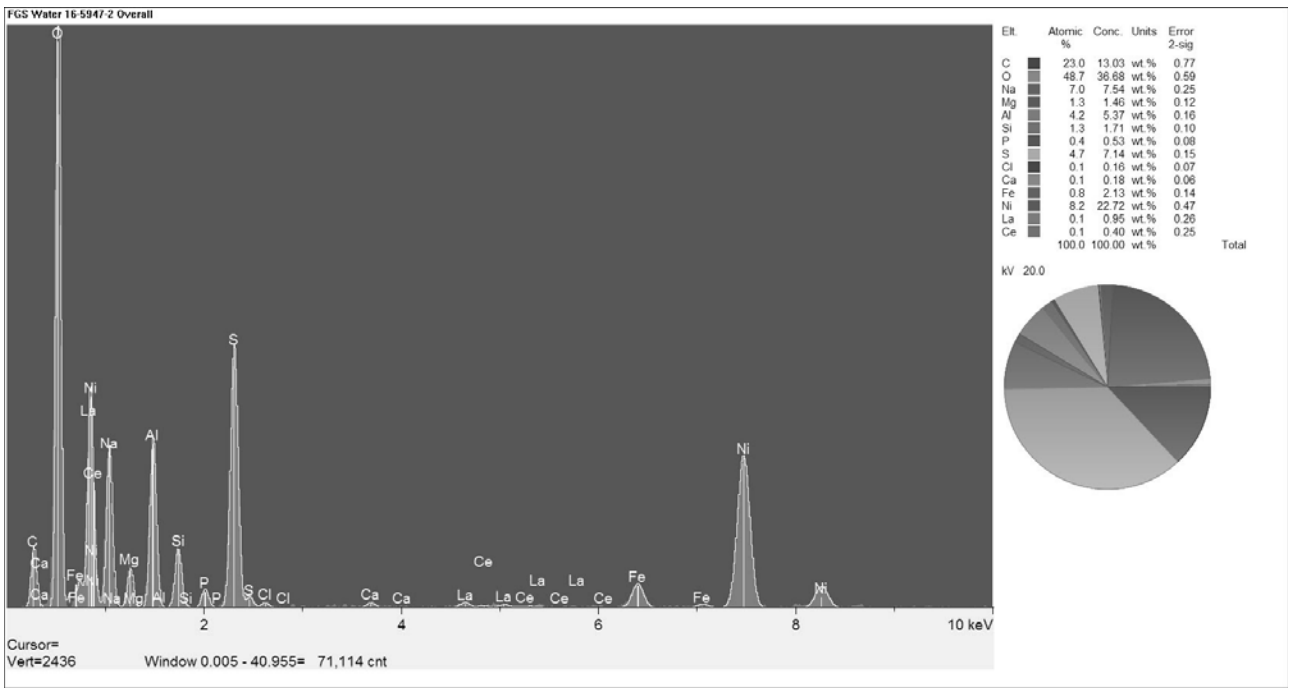


FIGURE 31
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 29

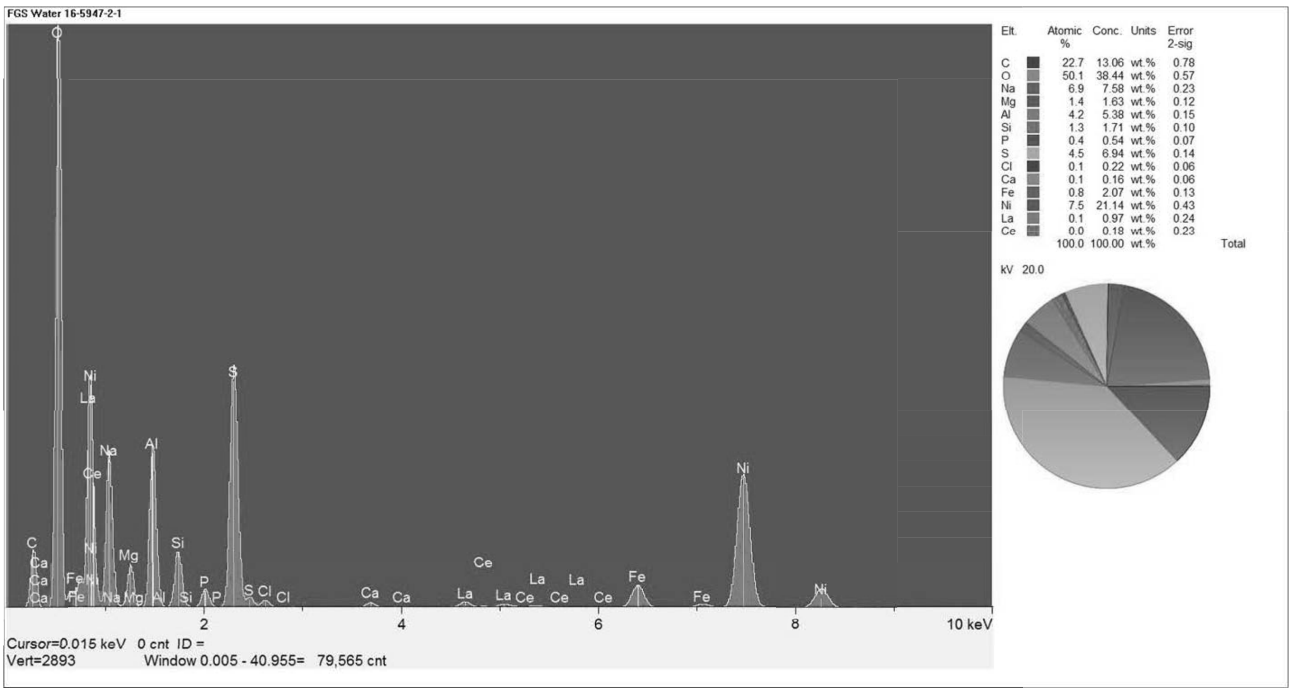


FIGURE 32
EDS MICROCHEMICAL ANALYSIS OF THE FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 29

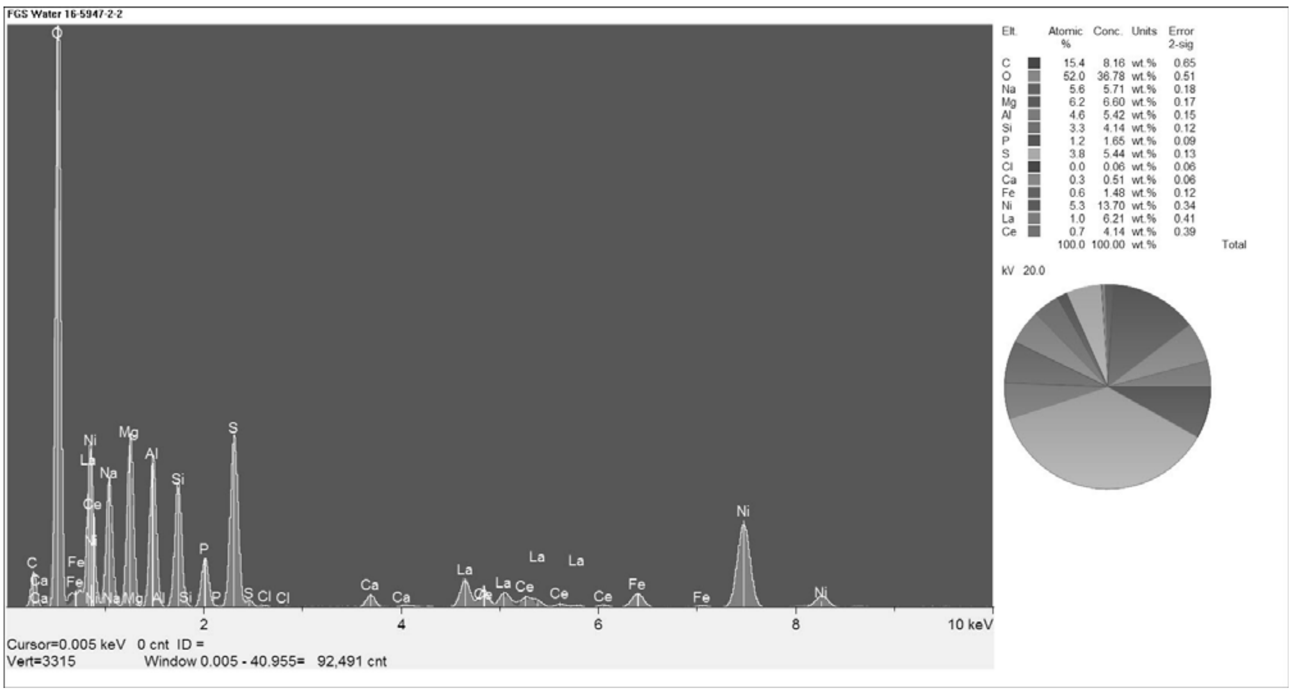


FIGURE 33
PHOTOGRAPH OF THE SRO SAMPLE PRECIPITATE

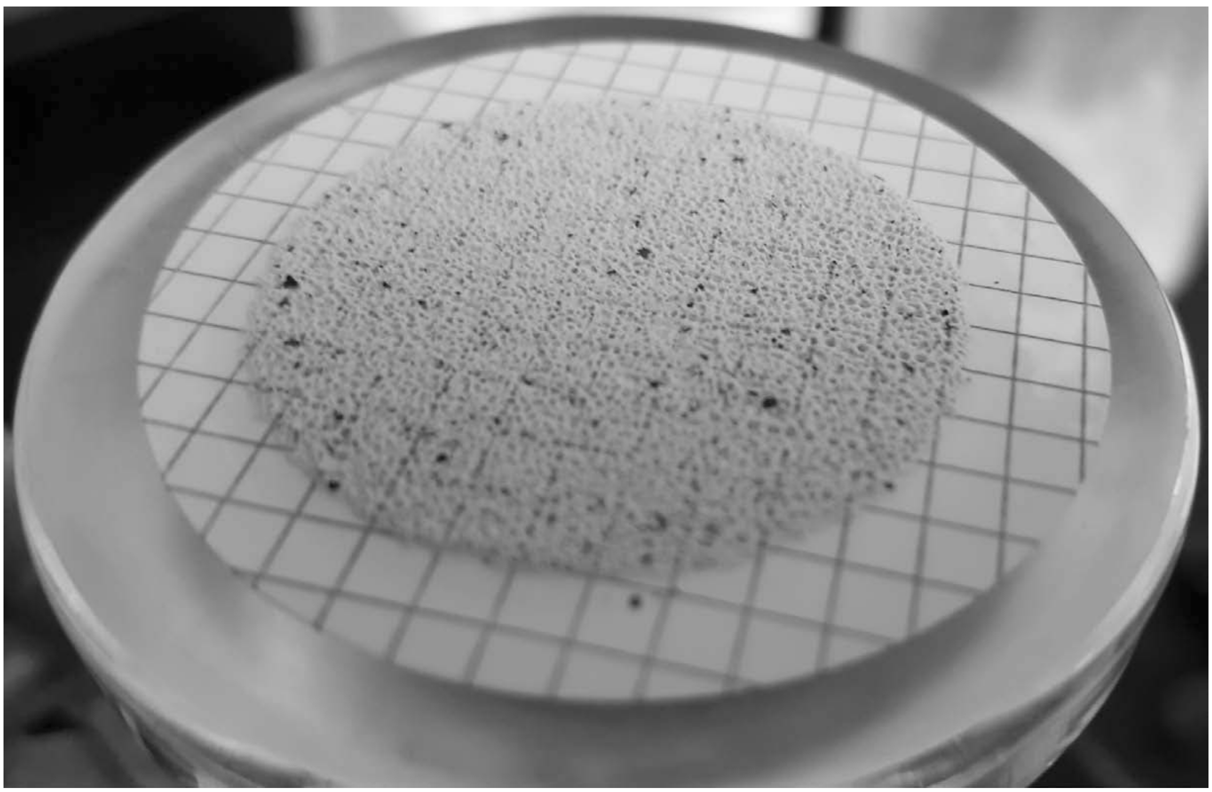


FIGURE 34
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE SRO SAMPLE PRECIPITATE

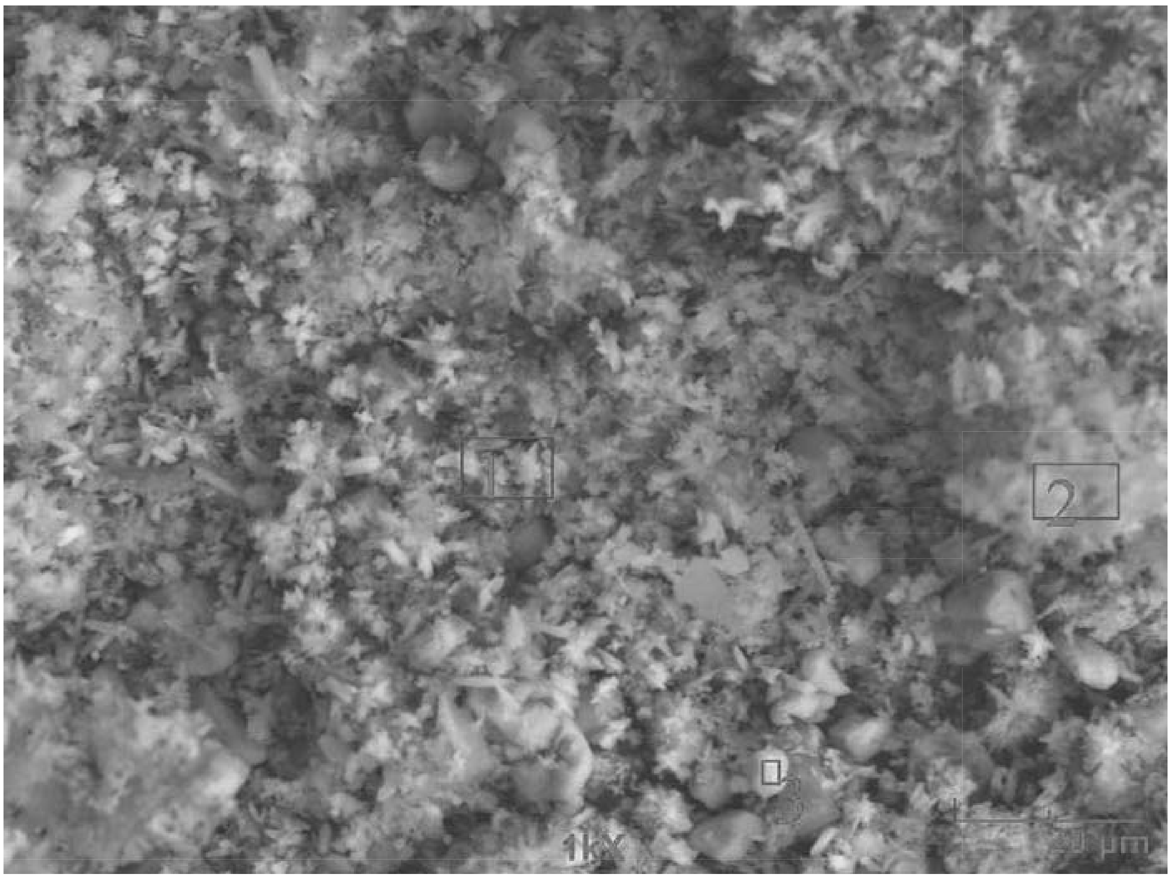


FIGURE 35
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 34

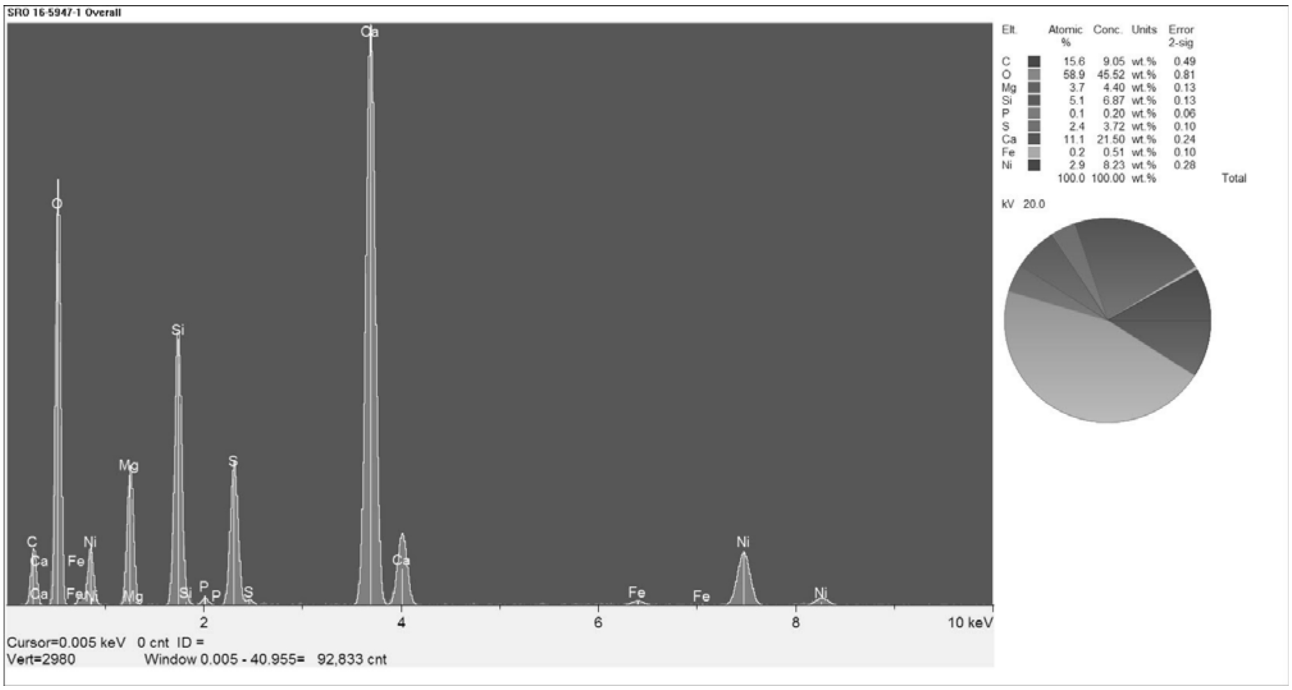


FIGURE 36
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 34

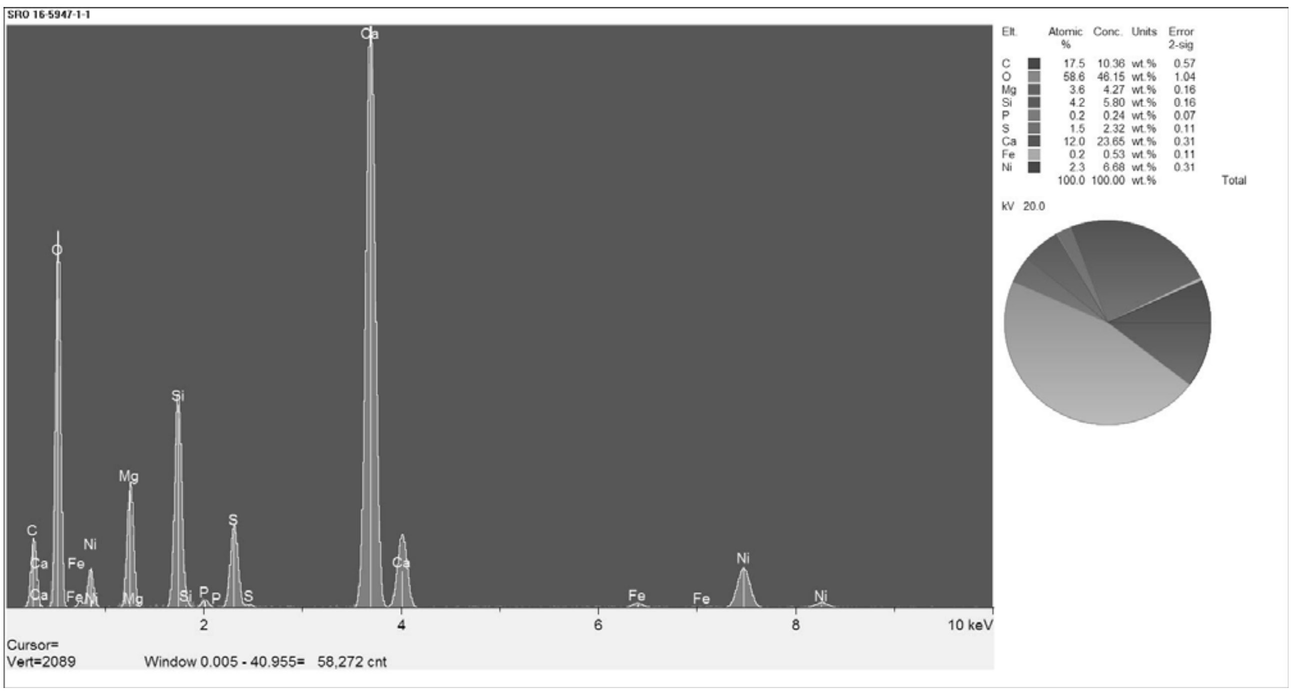


FIGURE 37
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 34

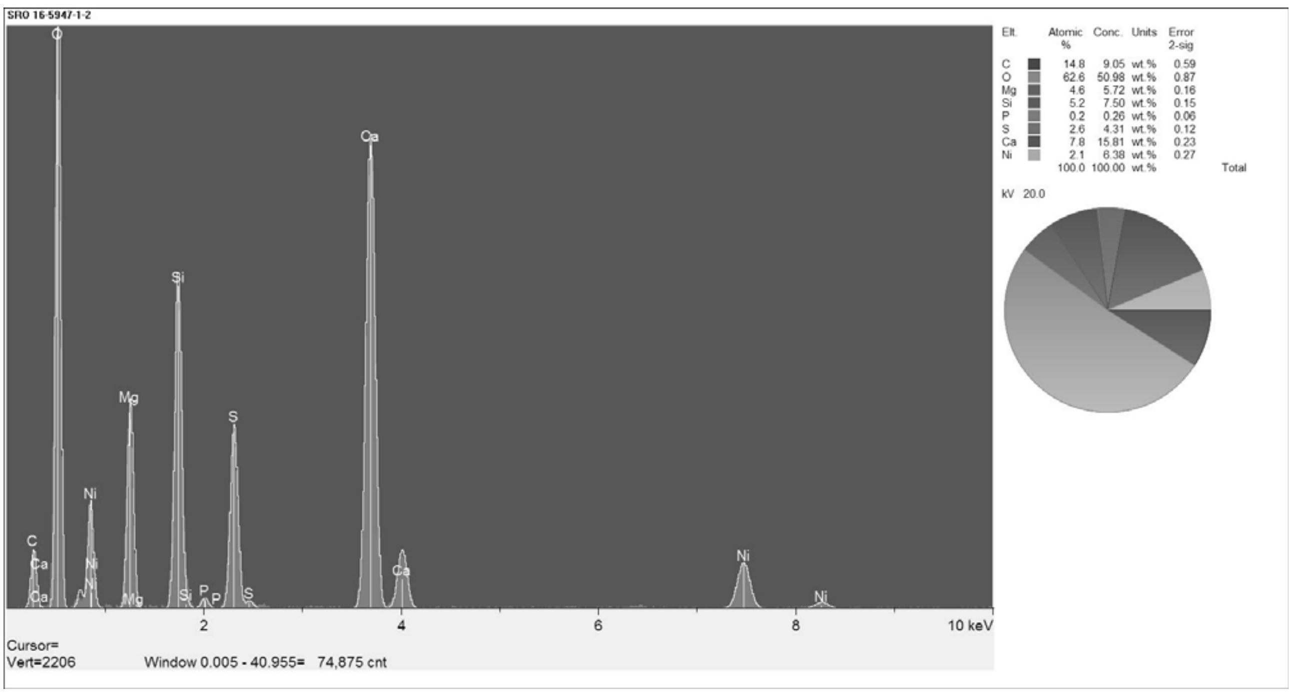


FIGURE 38
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES LABELED #3 IN FIGURE 34

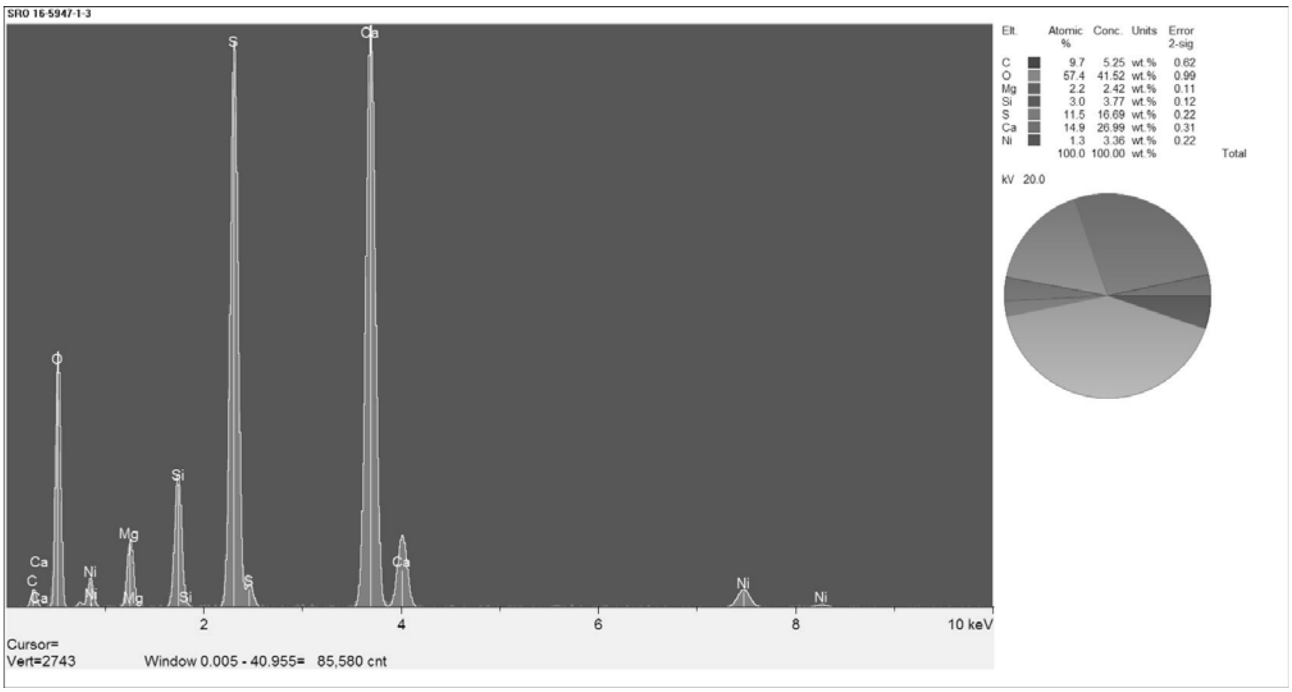


FIGURE 39
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE SRO SAMPLE PRECIPITATE

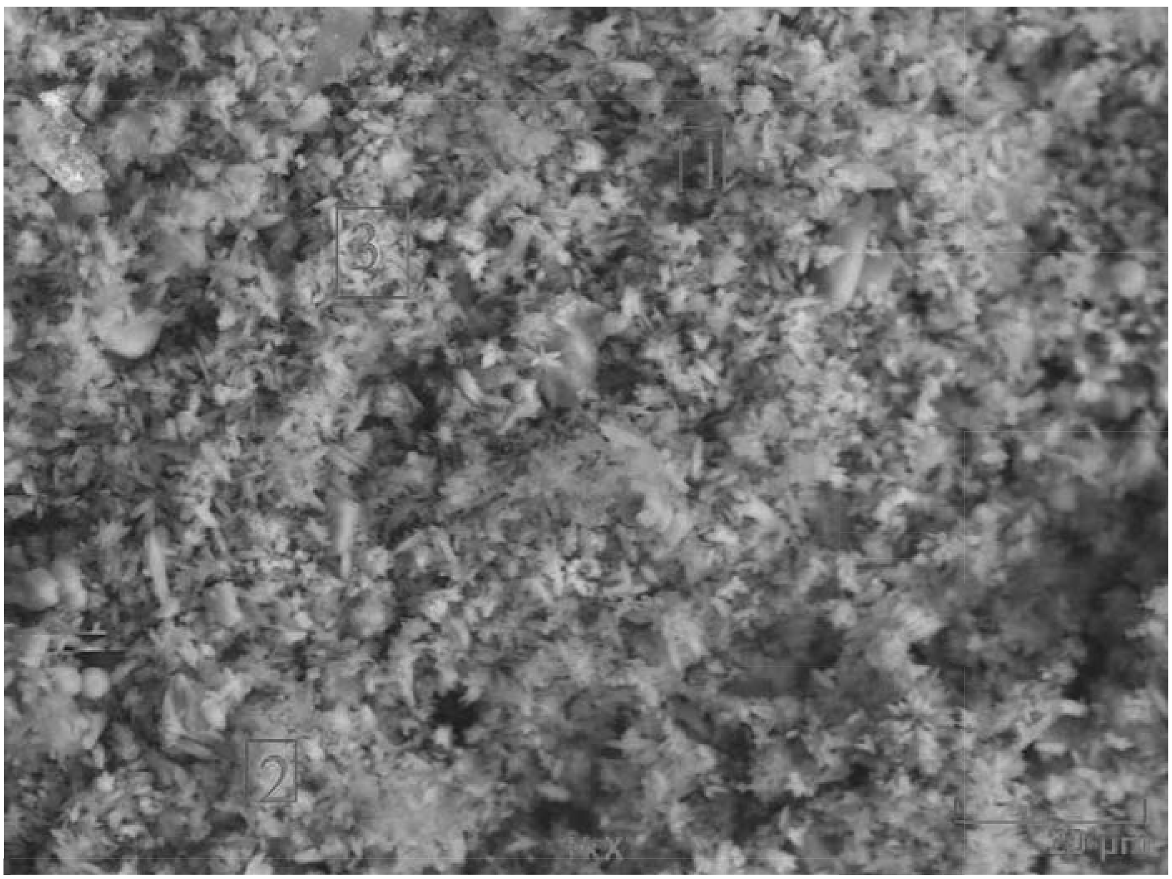


FIGURE 40
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 39

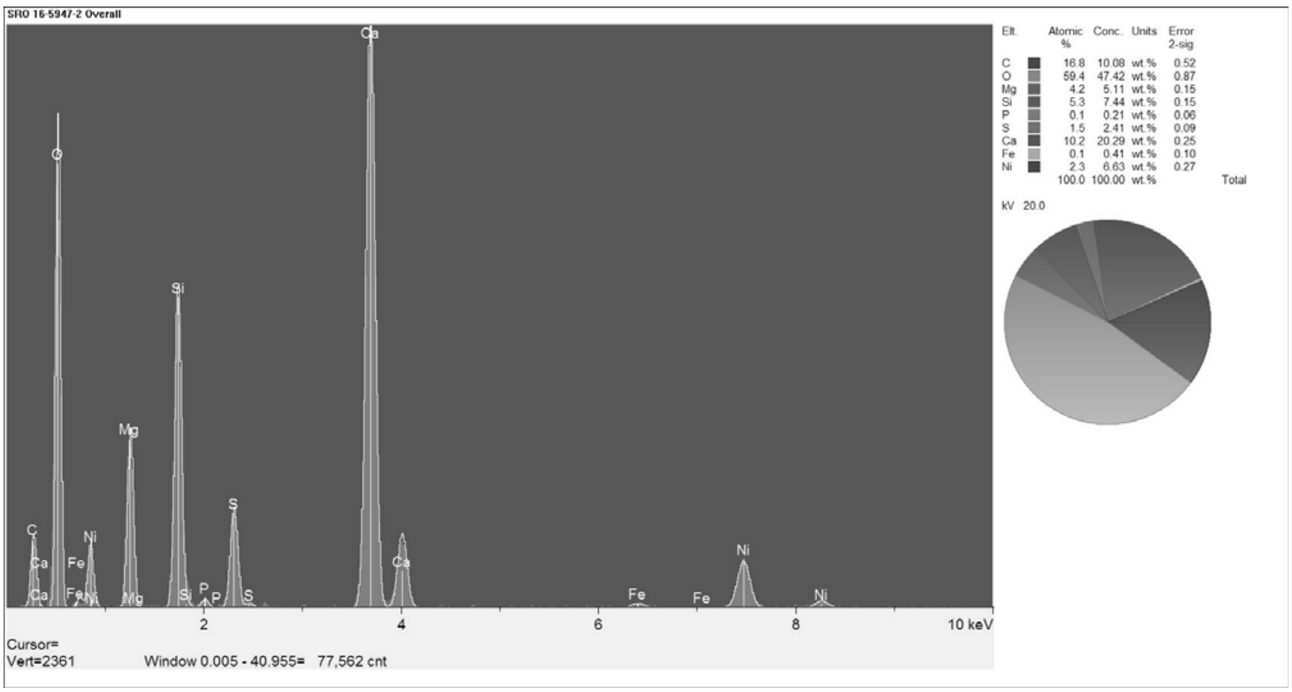


FIGURE 41
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 39

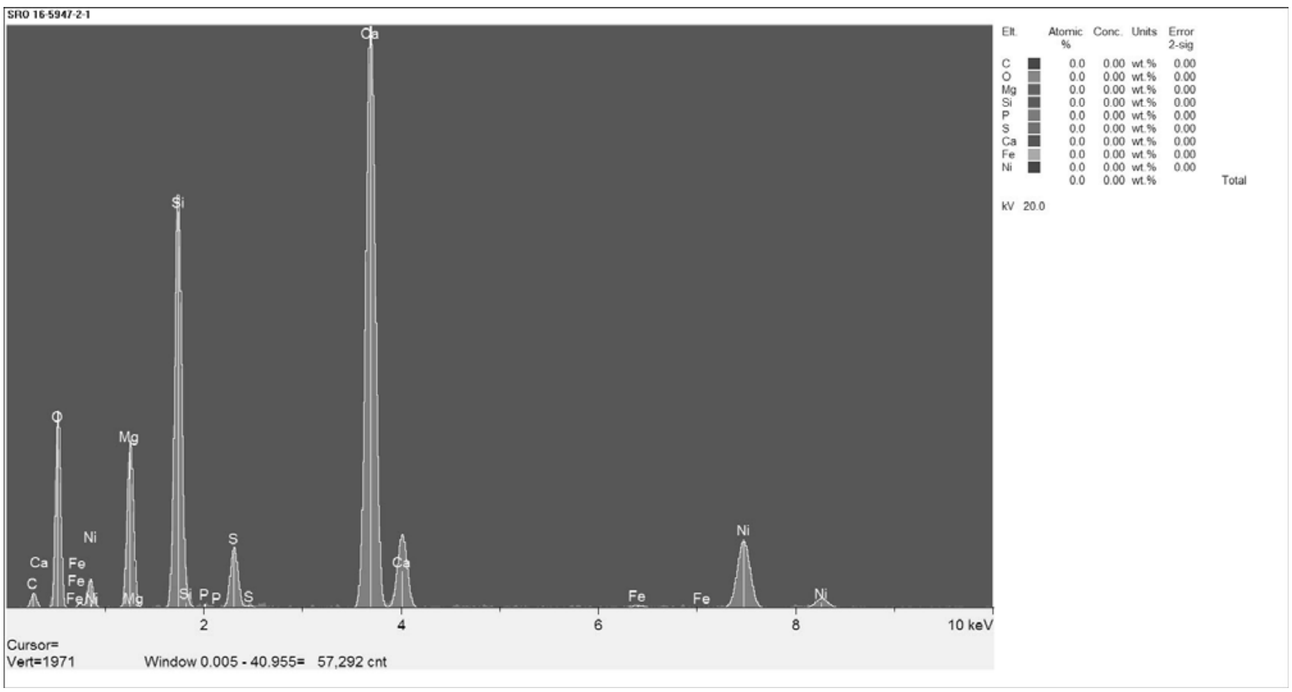


FIGURE 42
EDS MICROCHEMICAL ANALYSIS OF THE SRO SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 39

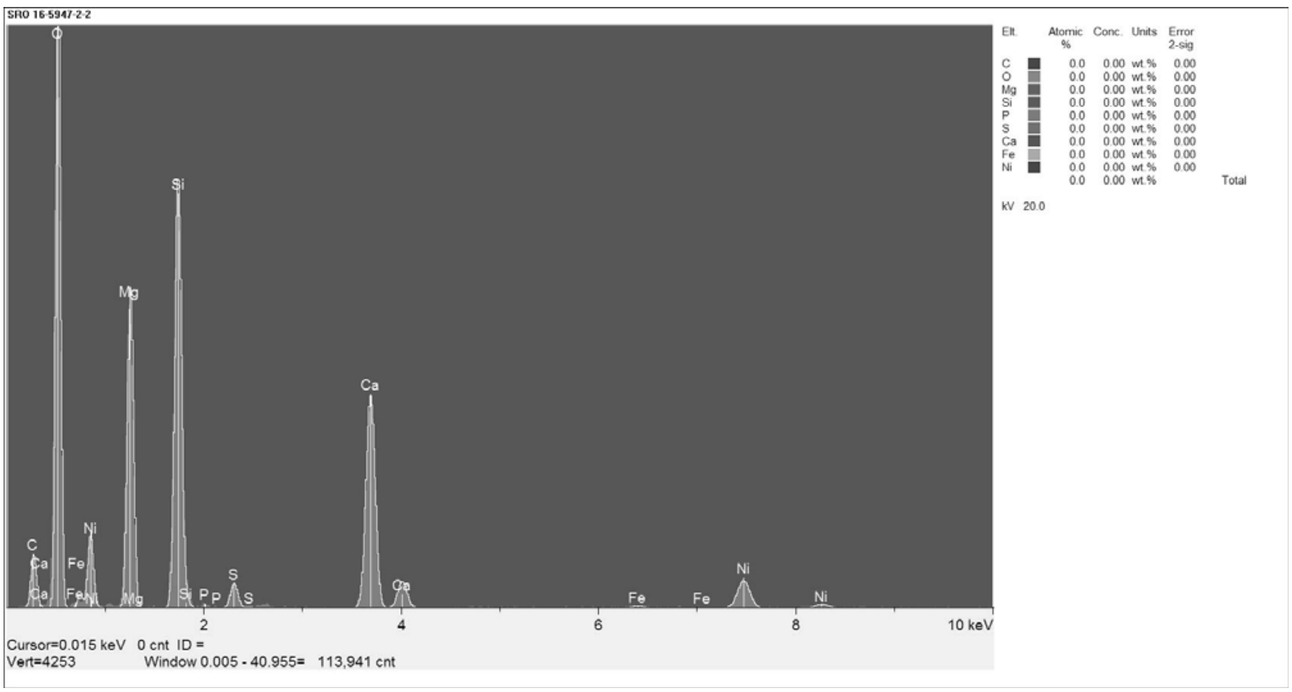


FIGURE 43
EDS MICROCHEMICAL ANALYSIS OF THE PARTICLES LABELED #3 IN FIGURE 39

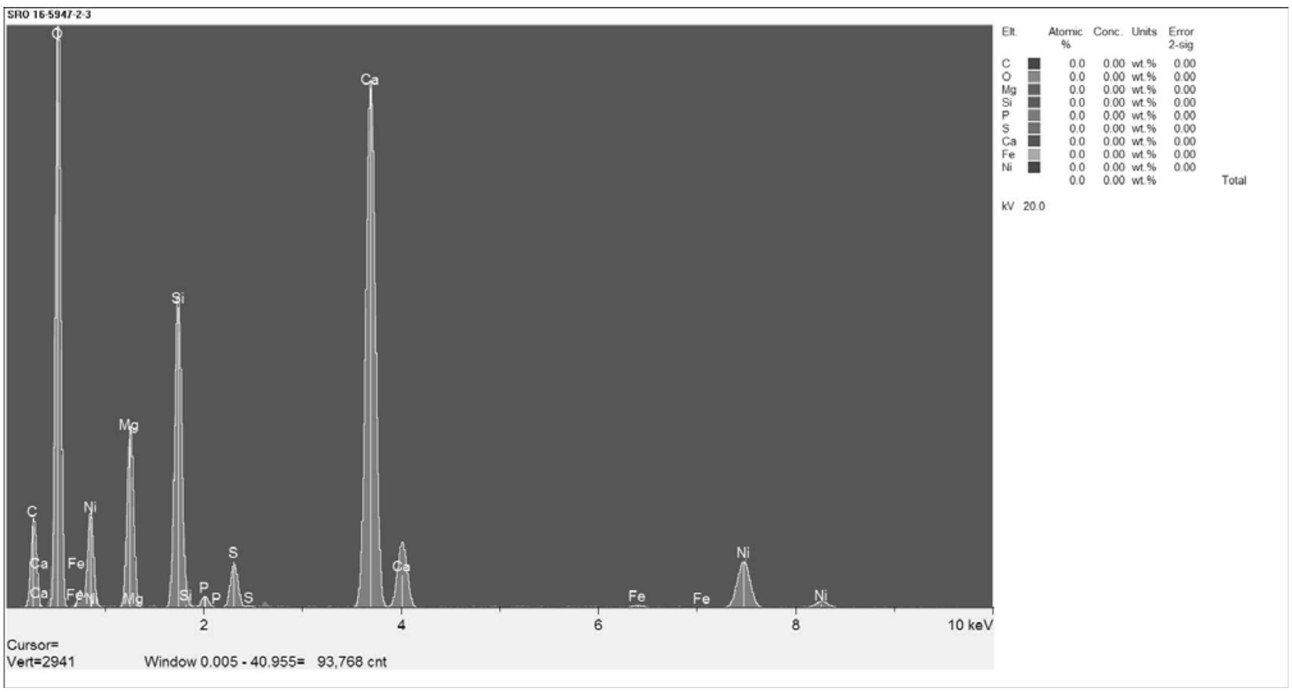


FIGURE 44
PHOTOGRAPH OF THE WWFGS SAMPLE PRECIPITATE

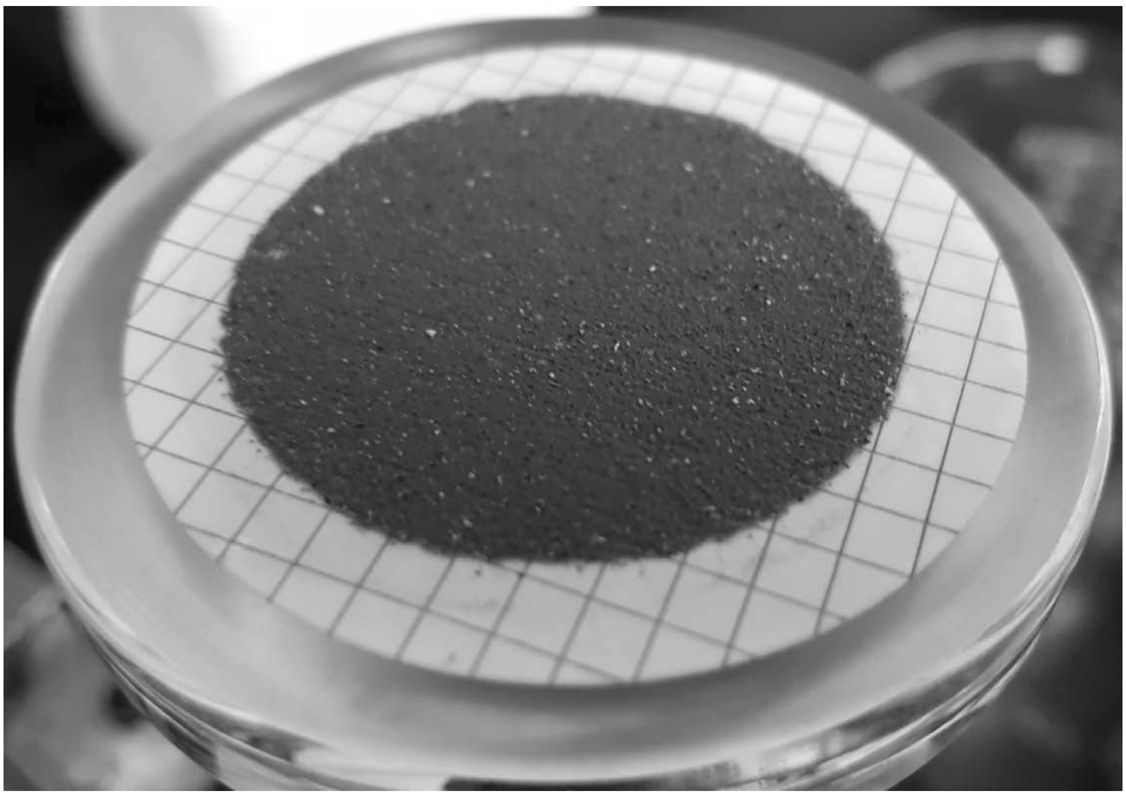


FIGURE 45
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE WWFGS SAMPLE PRECIPITATE

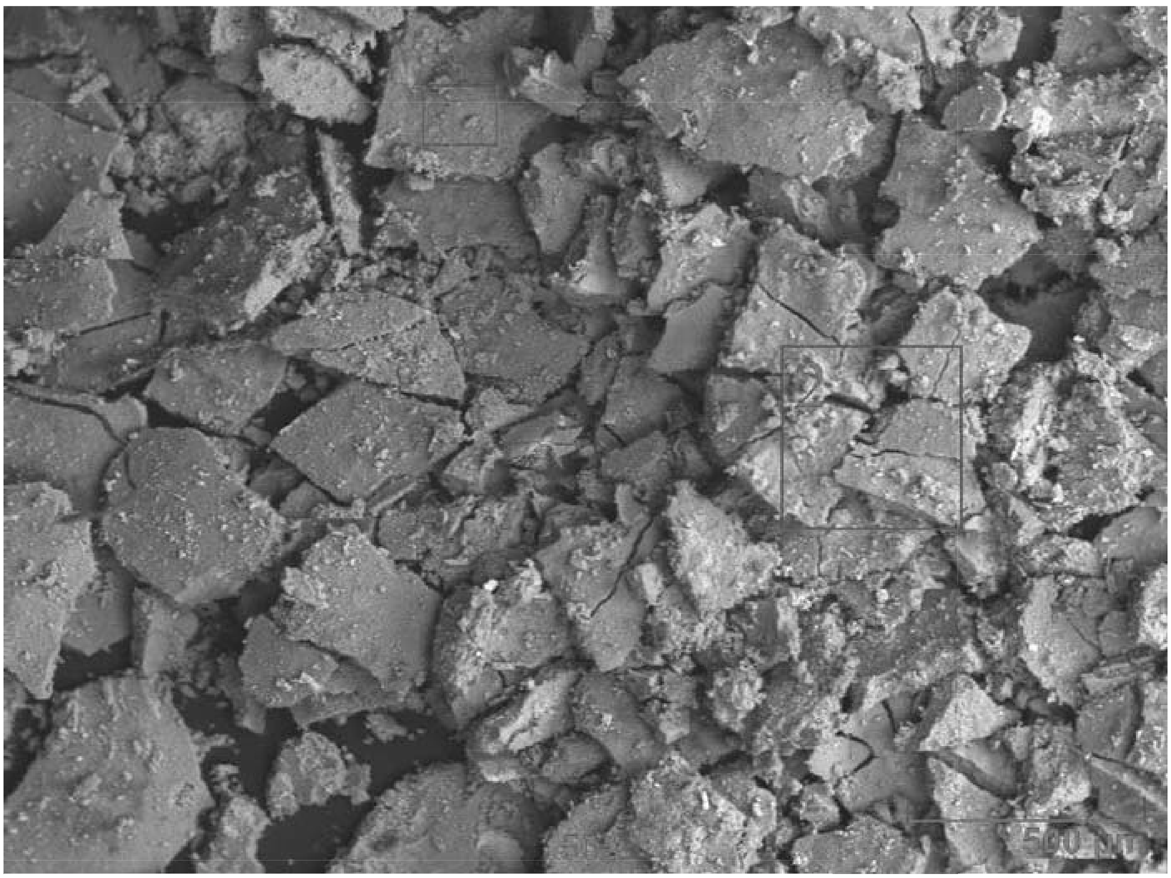


FIGURE 46
EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 45

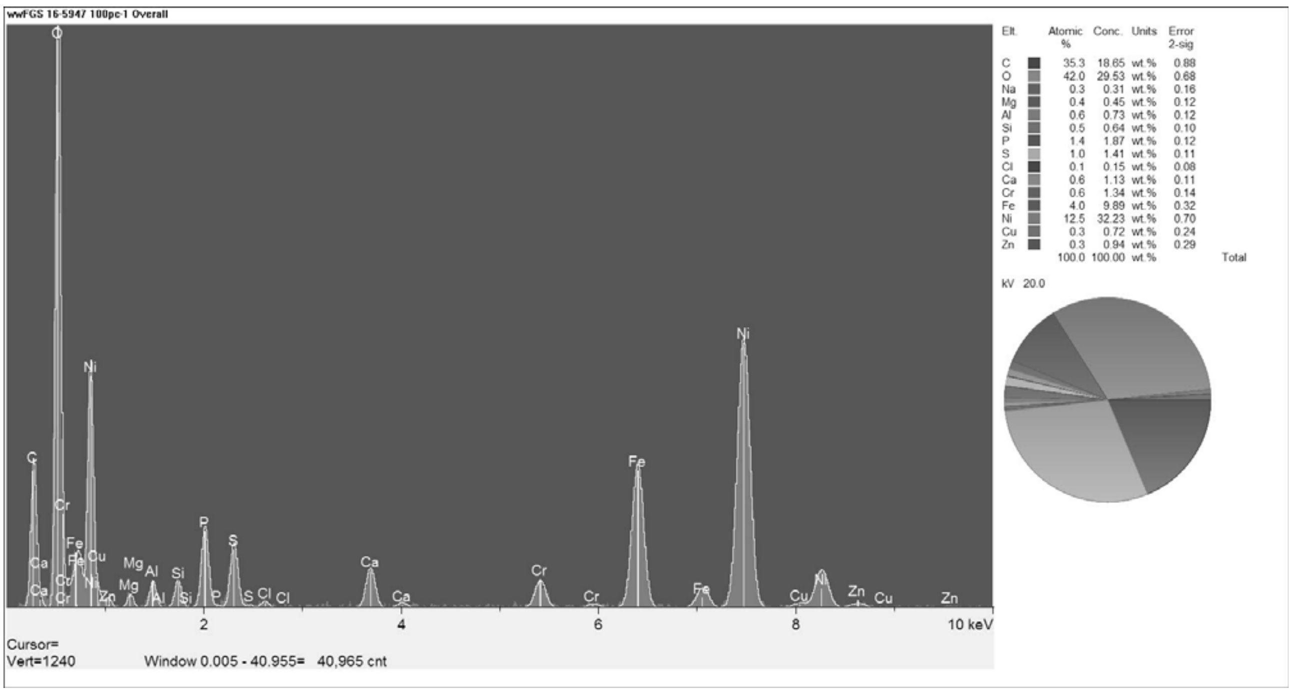


FIGURE 47
EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 45

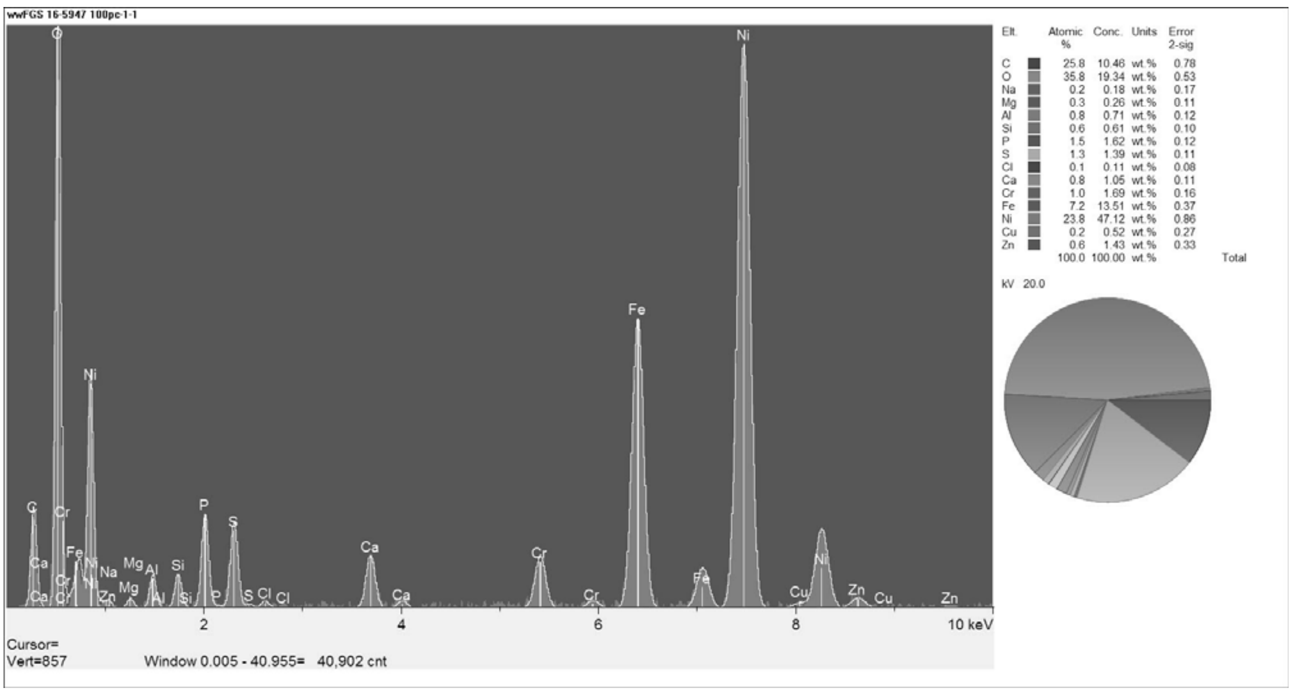


FIGURE 48

EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 45

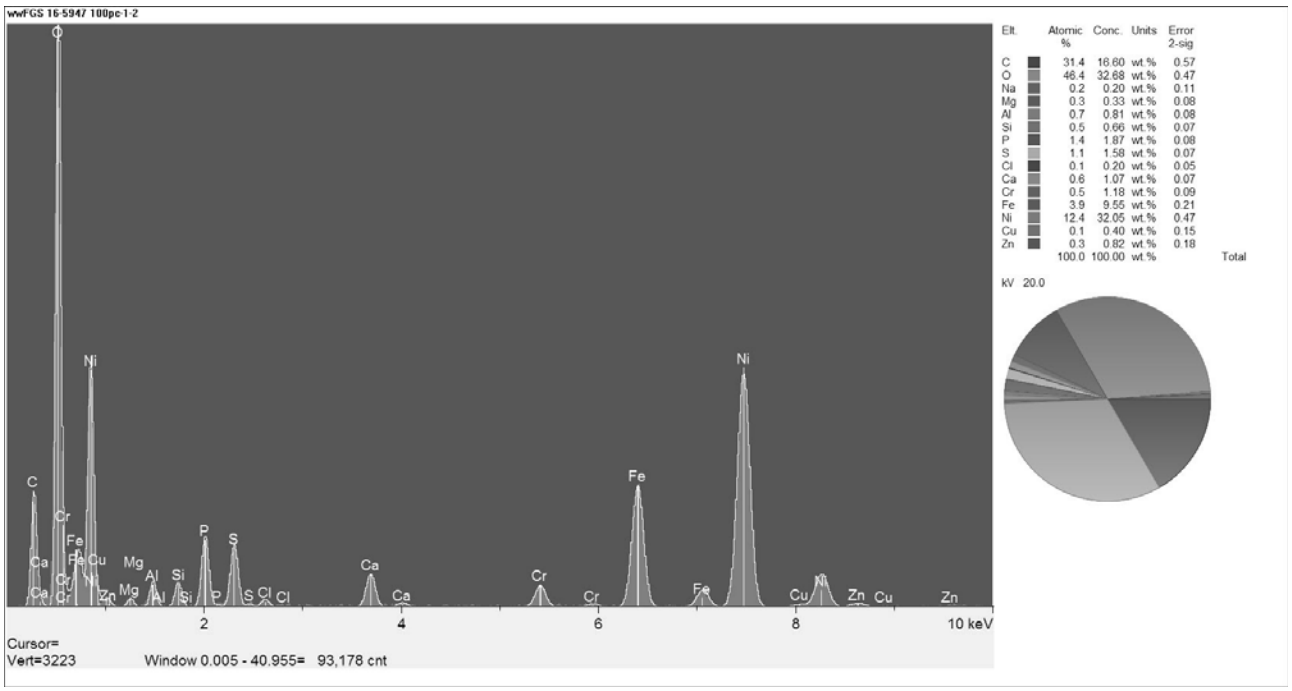


FIGURE 49
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE WWFGS SAMPLE PRECIPITATE

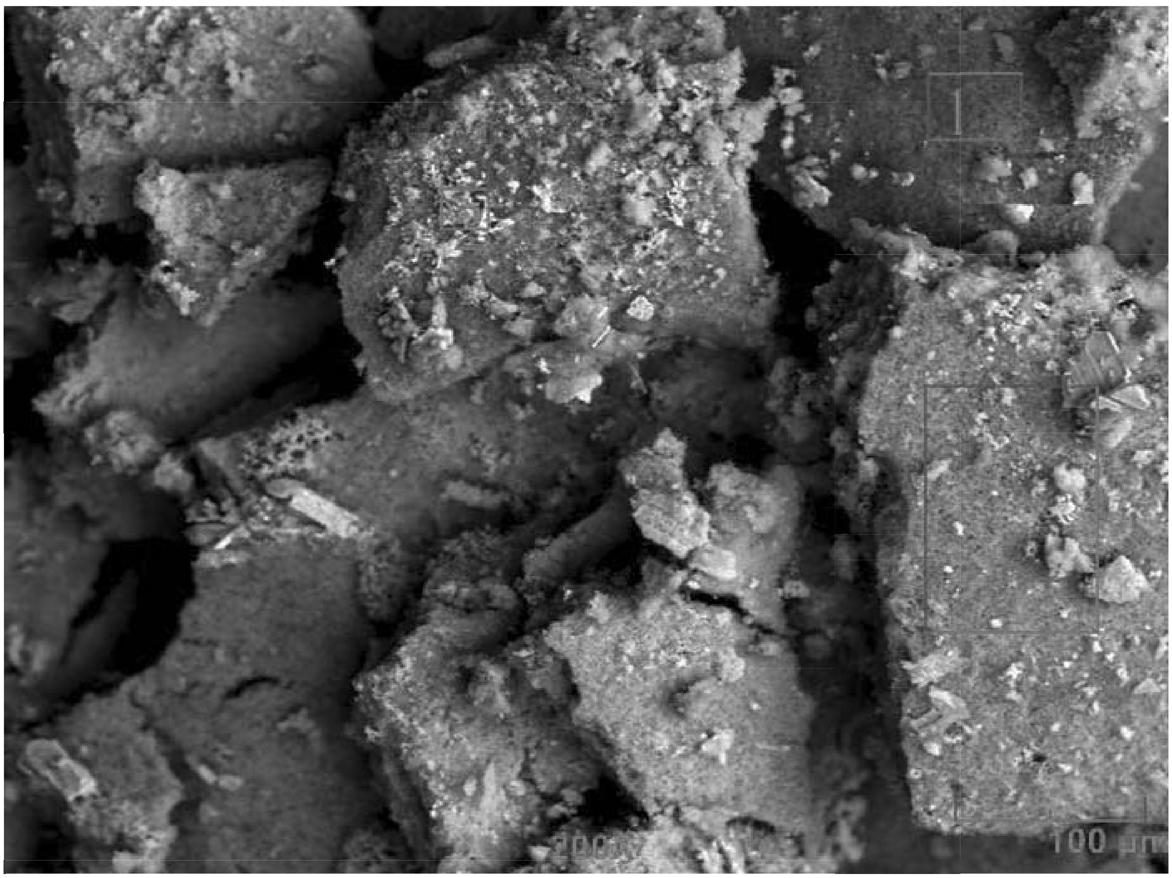


FIGURE 50
EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 49

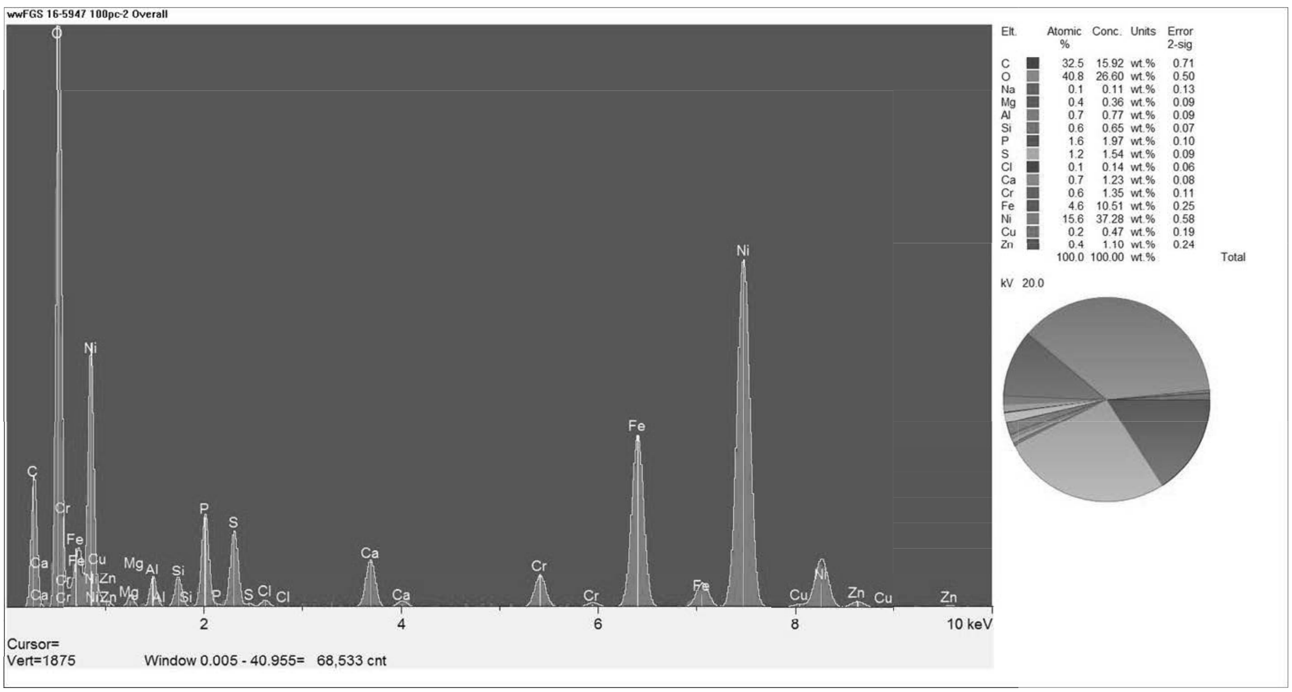


FIGURE 51
EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 49

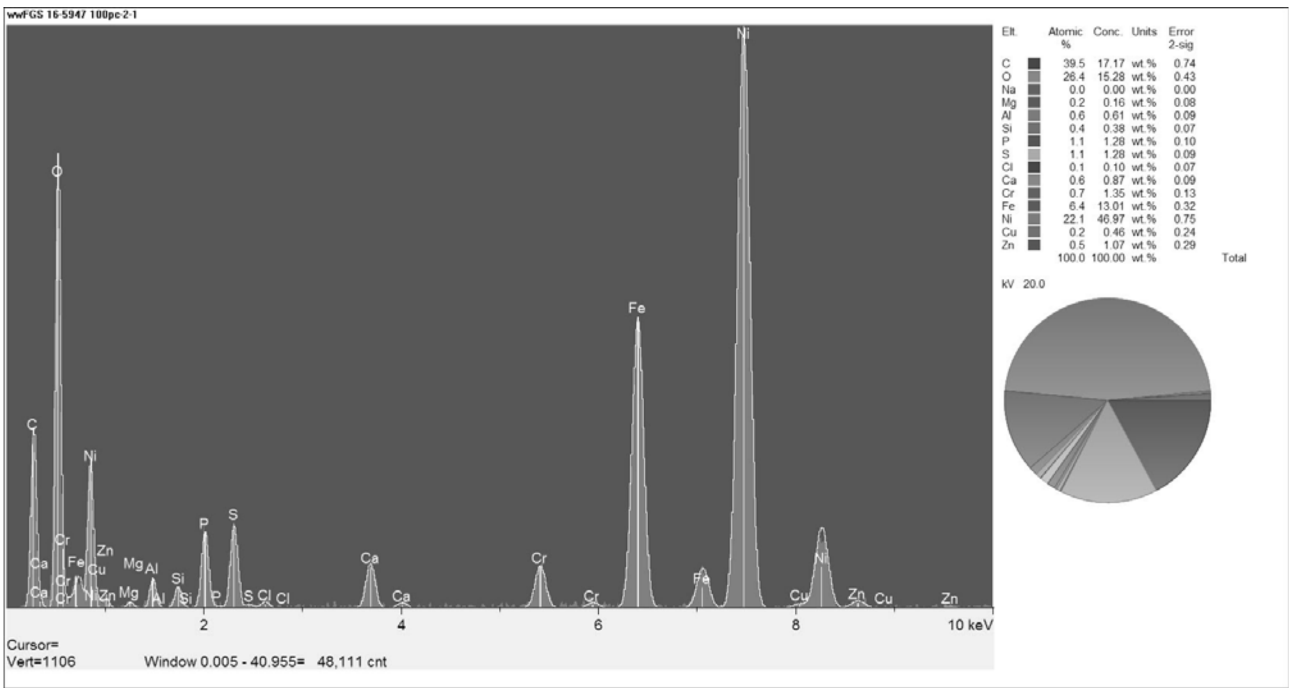


FIGURE 52
EDS MICROCHEMICAL ANALYSIS OF THE WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 49

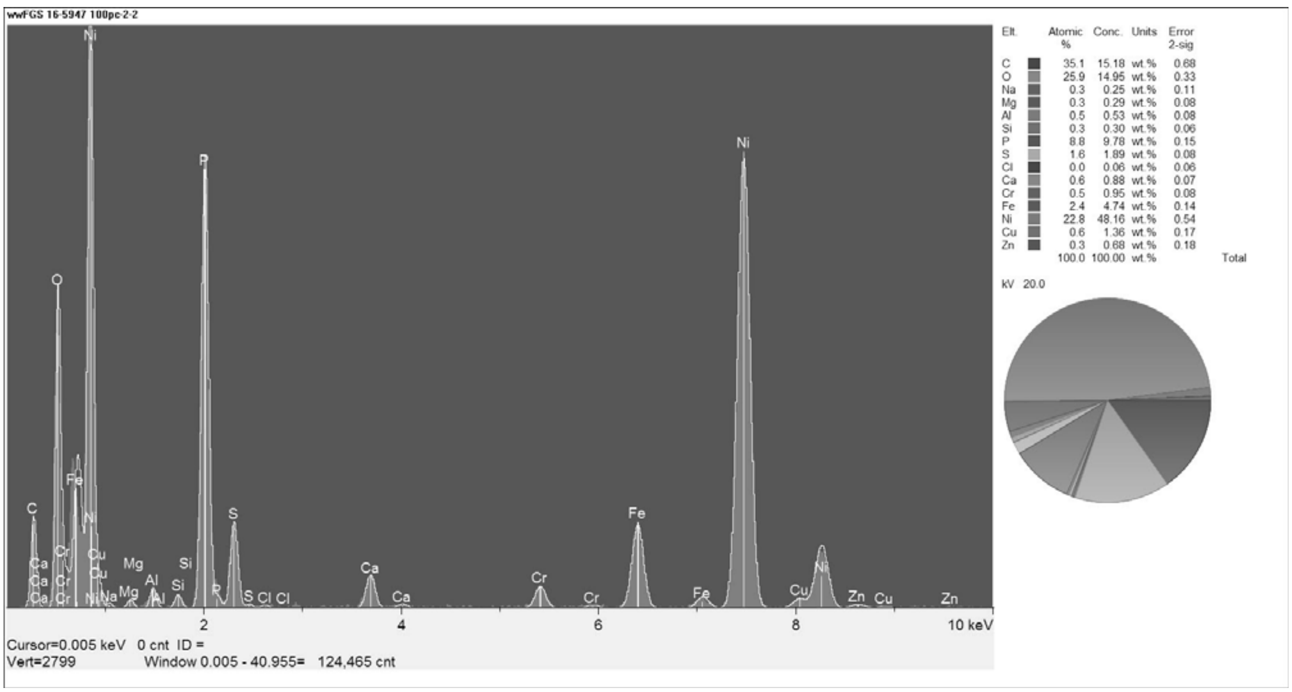


FIGURE 53
PHOTOGRAPH OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE

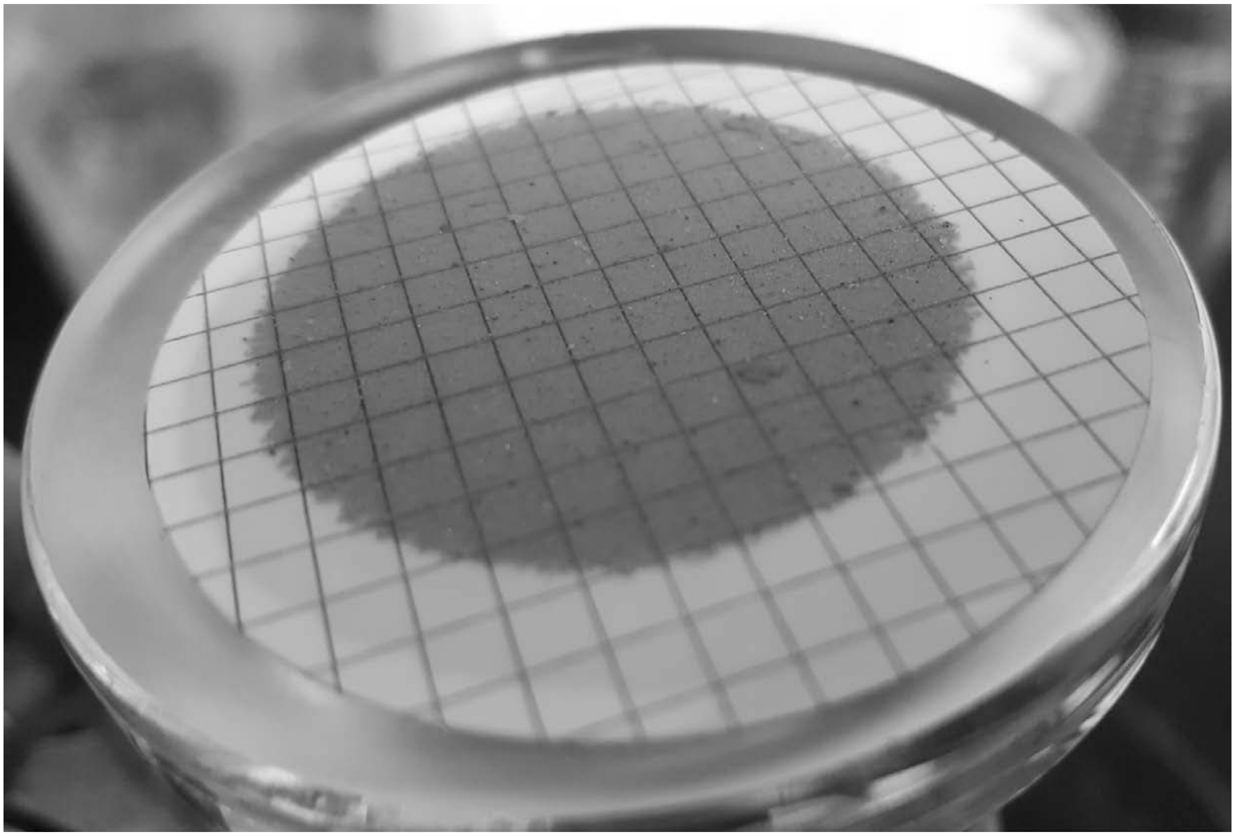


FIGURE 54
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE

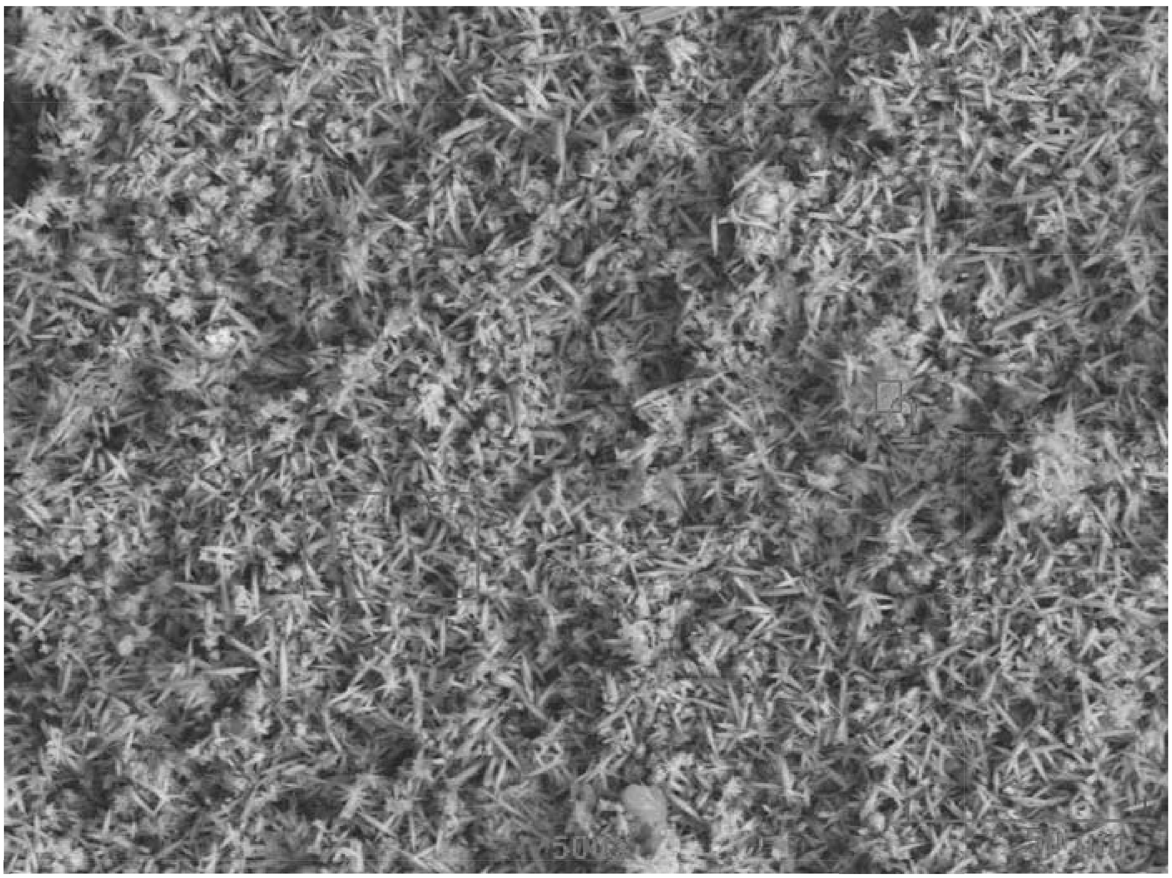


FIGURE 55
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 54

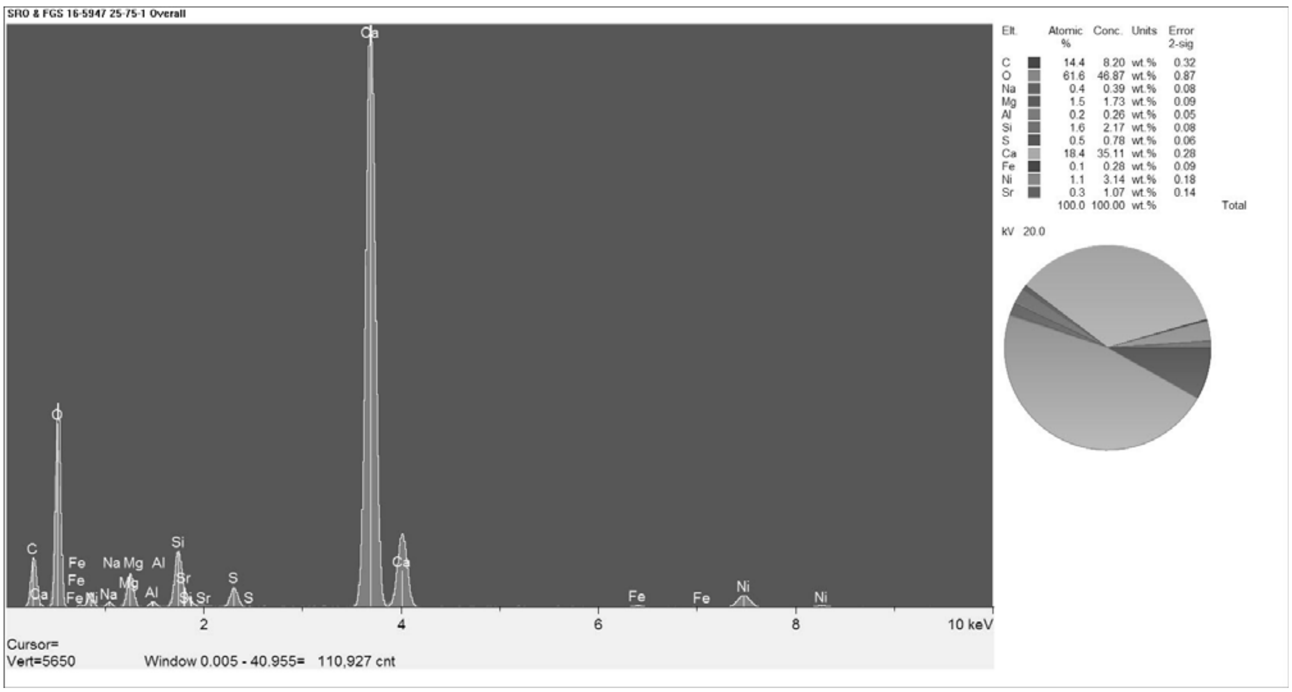


FIGURE 56
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 54

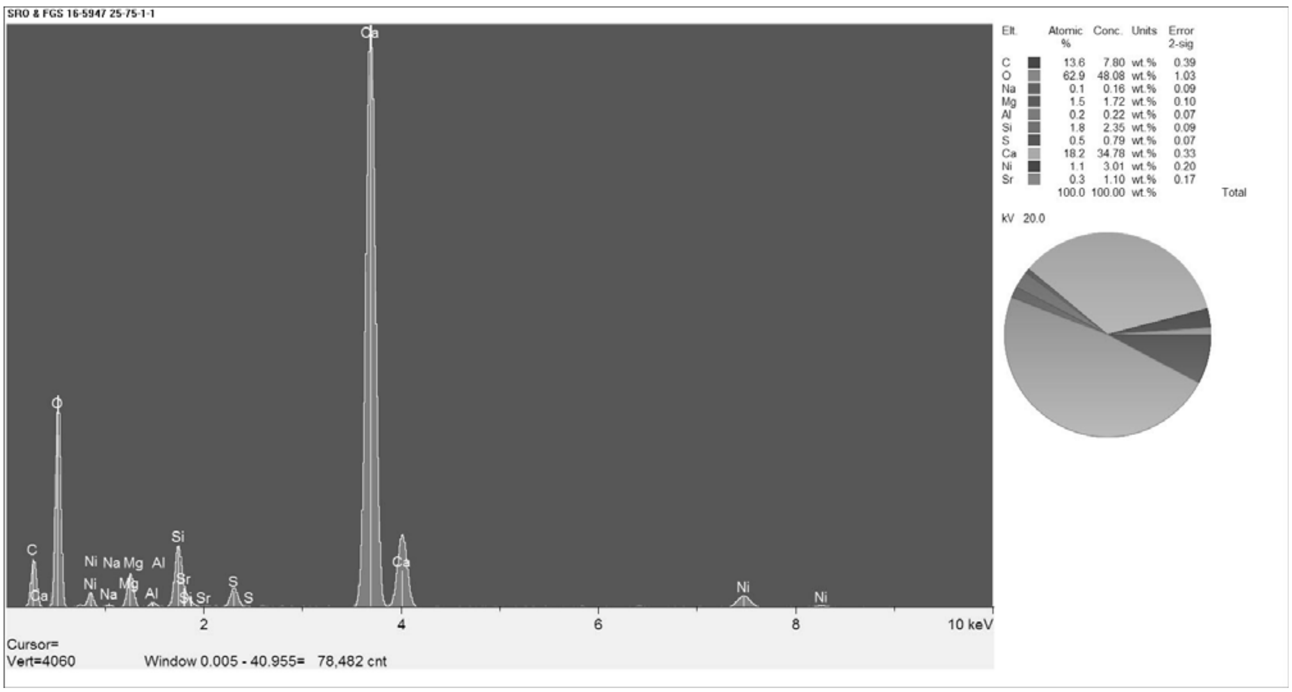


FIGURE 57
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE

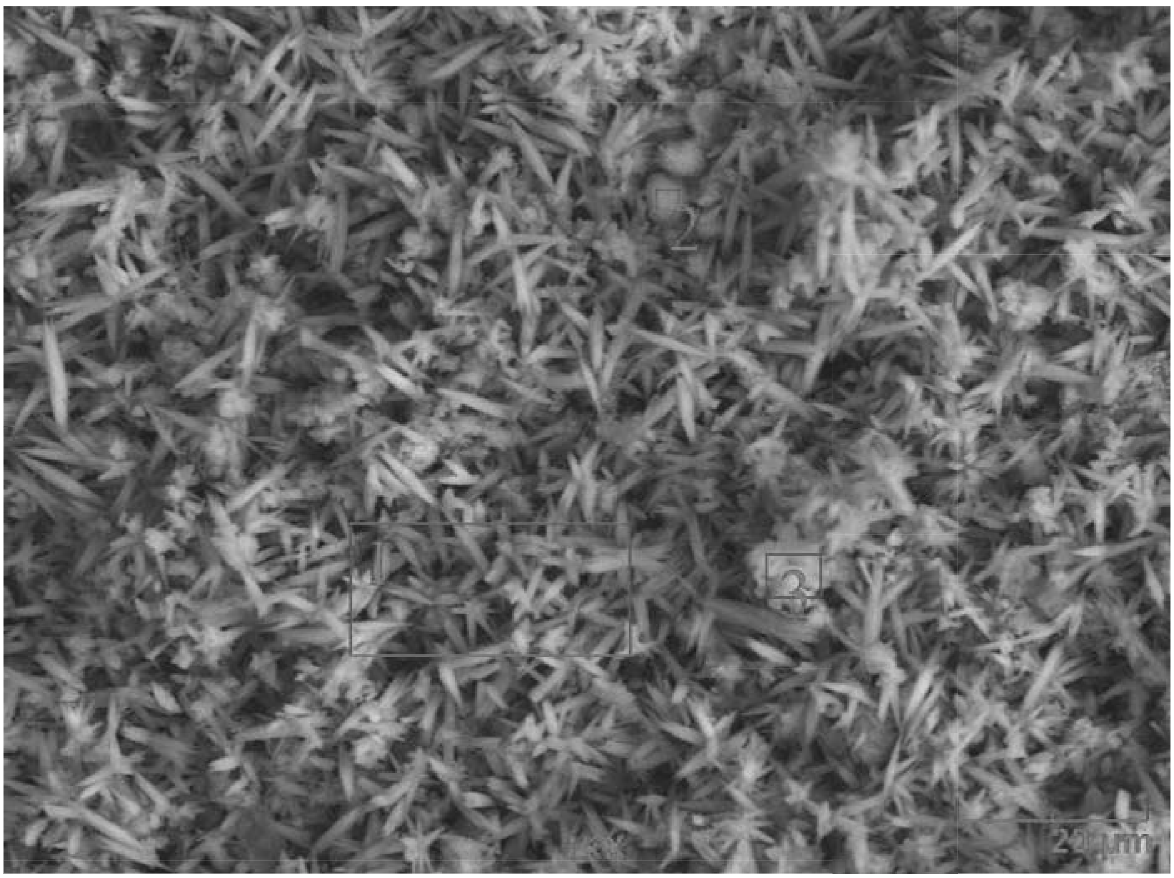


FIGURE 58
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 57

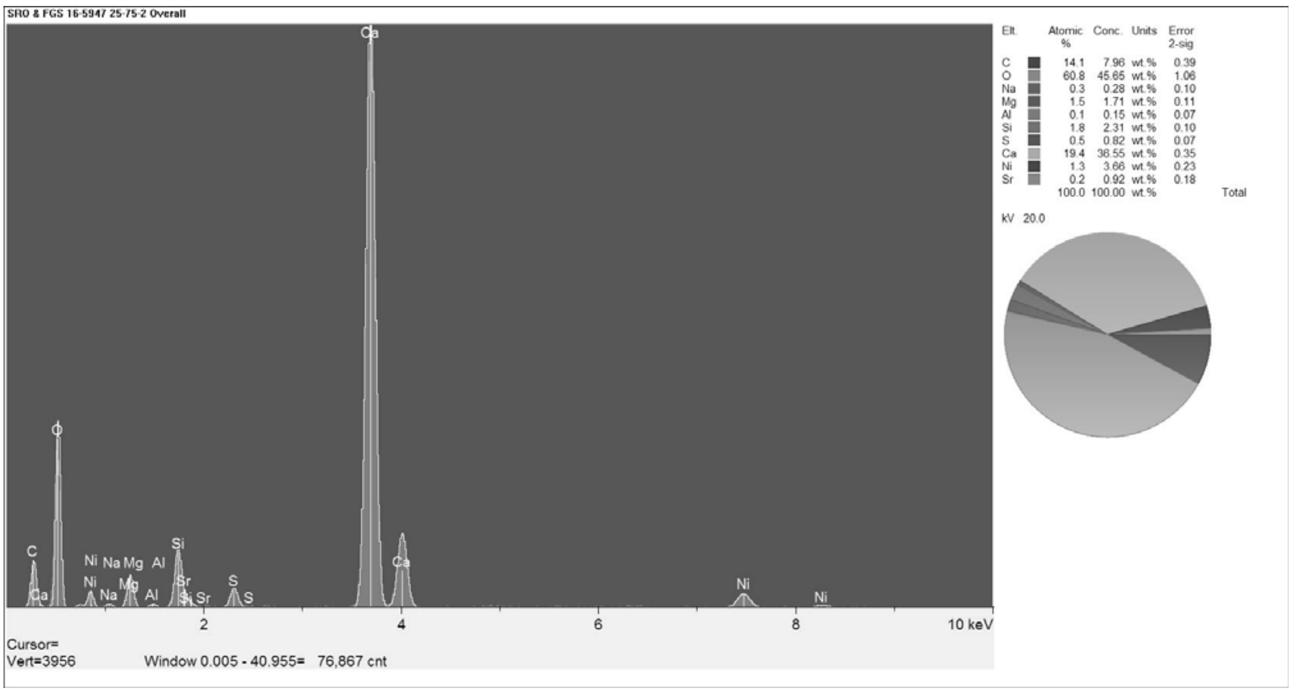


FIGURE 59
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 57

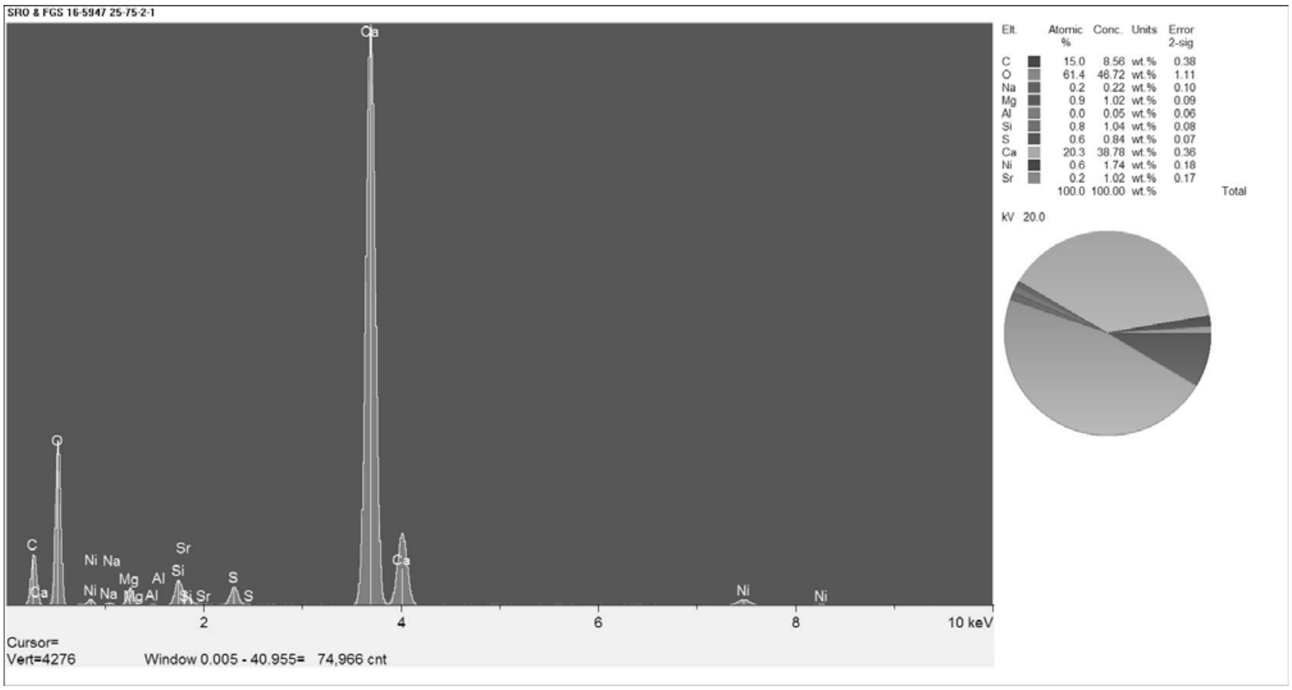


FIGURE 60
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 57

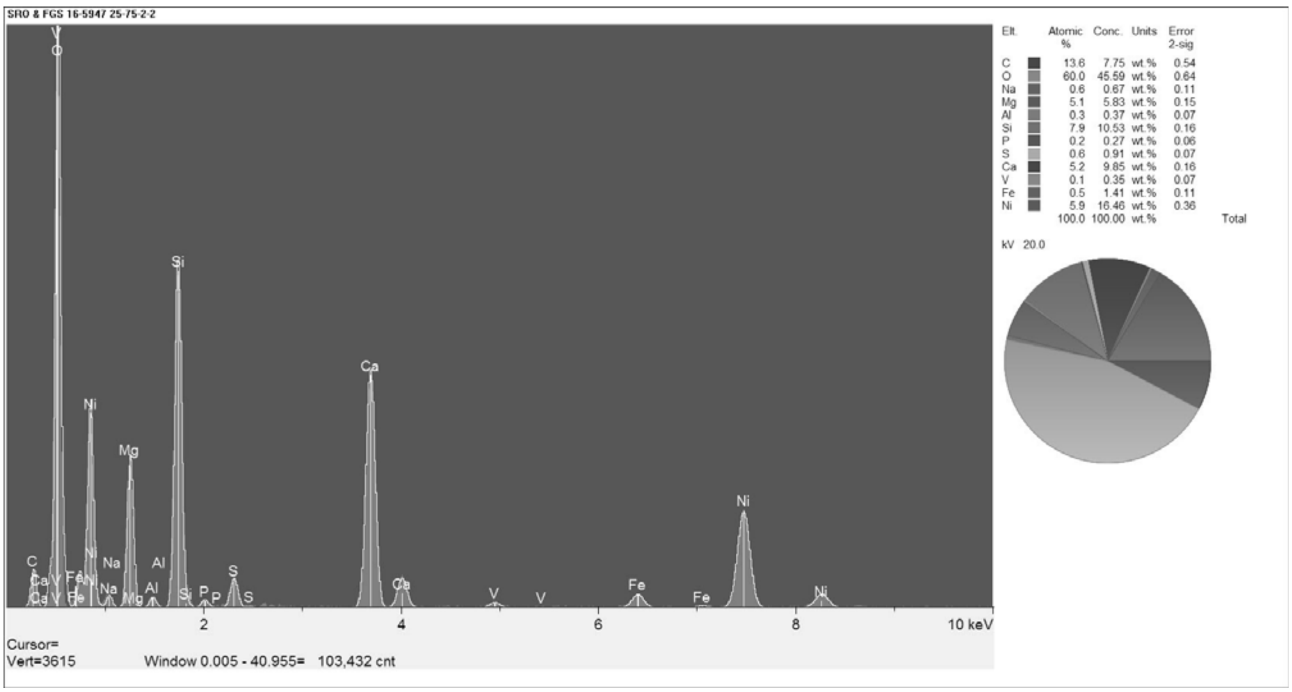


FIGURE 61
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #3 IN FIGURE 57

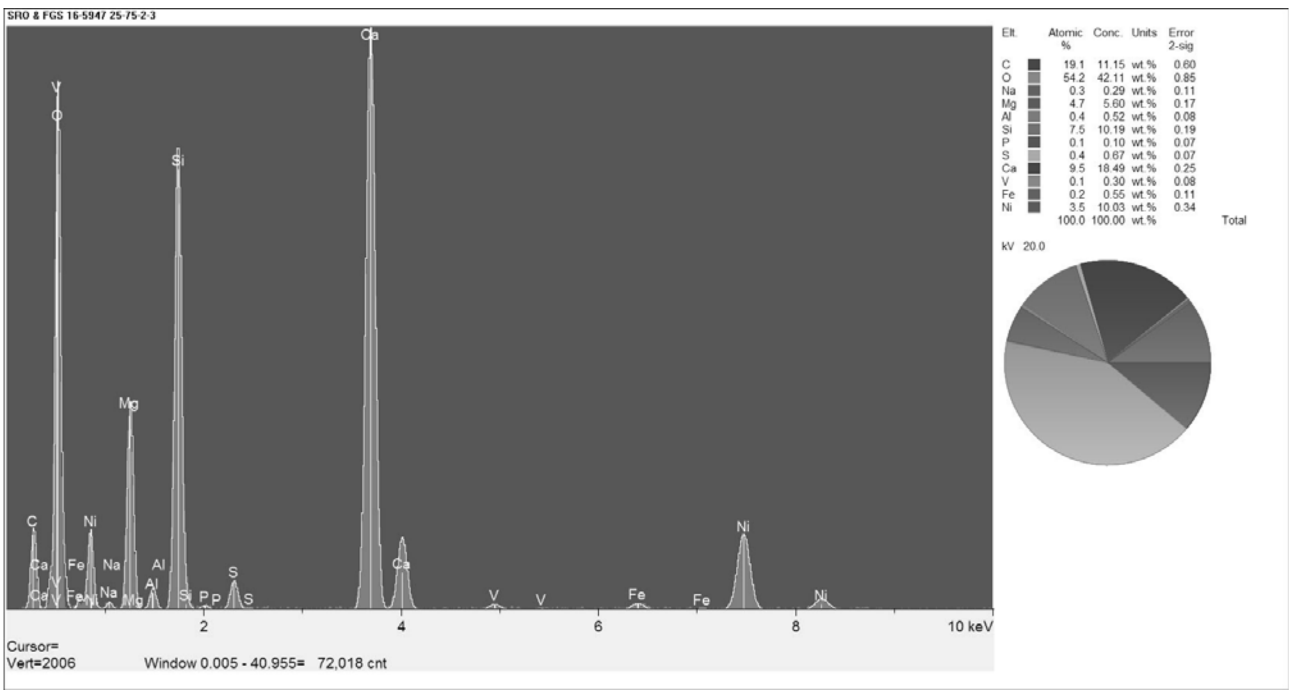


FIGURE 62
PHOTOGRAPH OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE

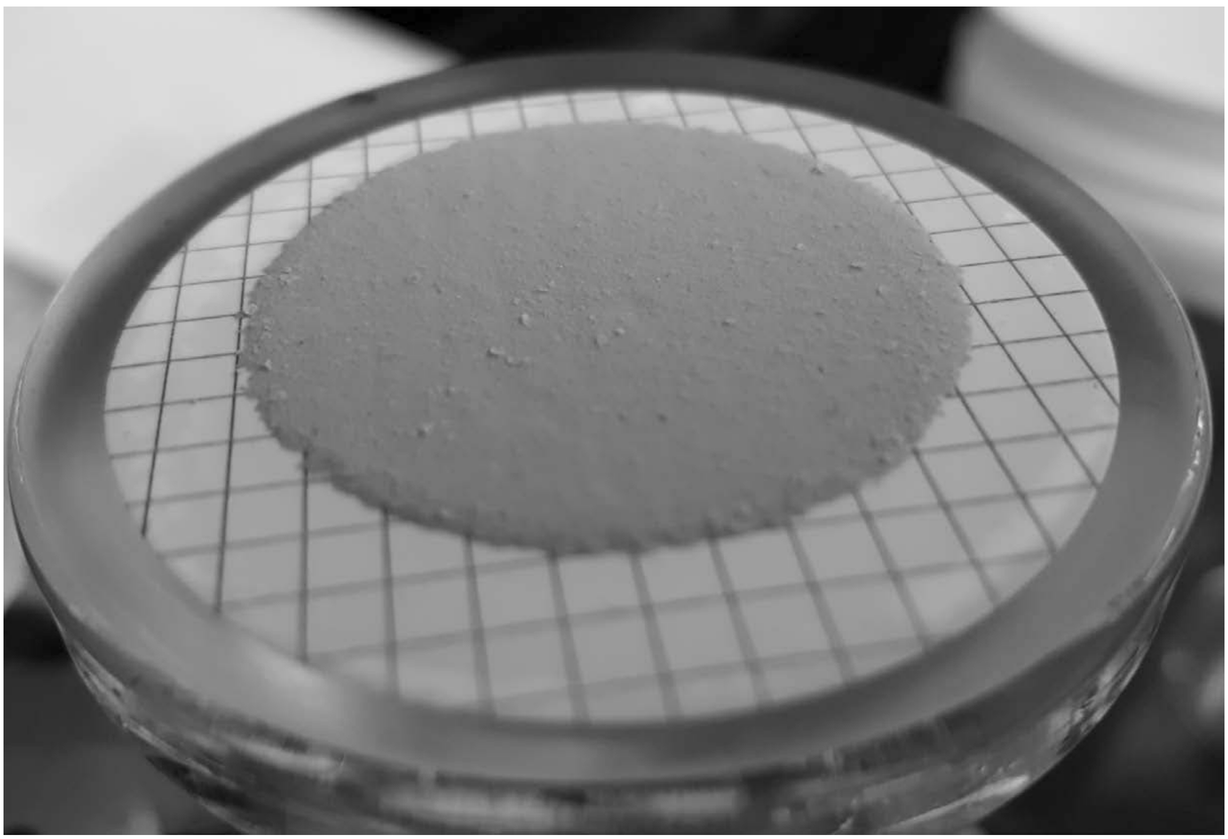


FIGURE 63
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE

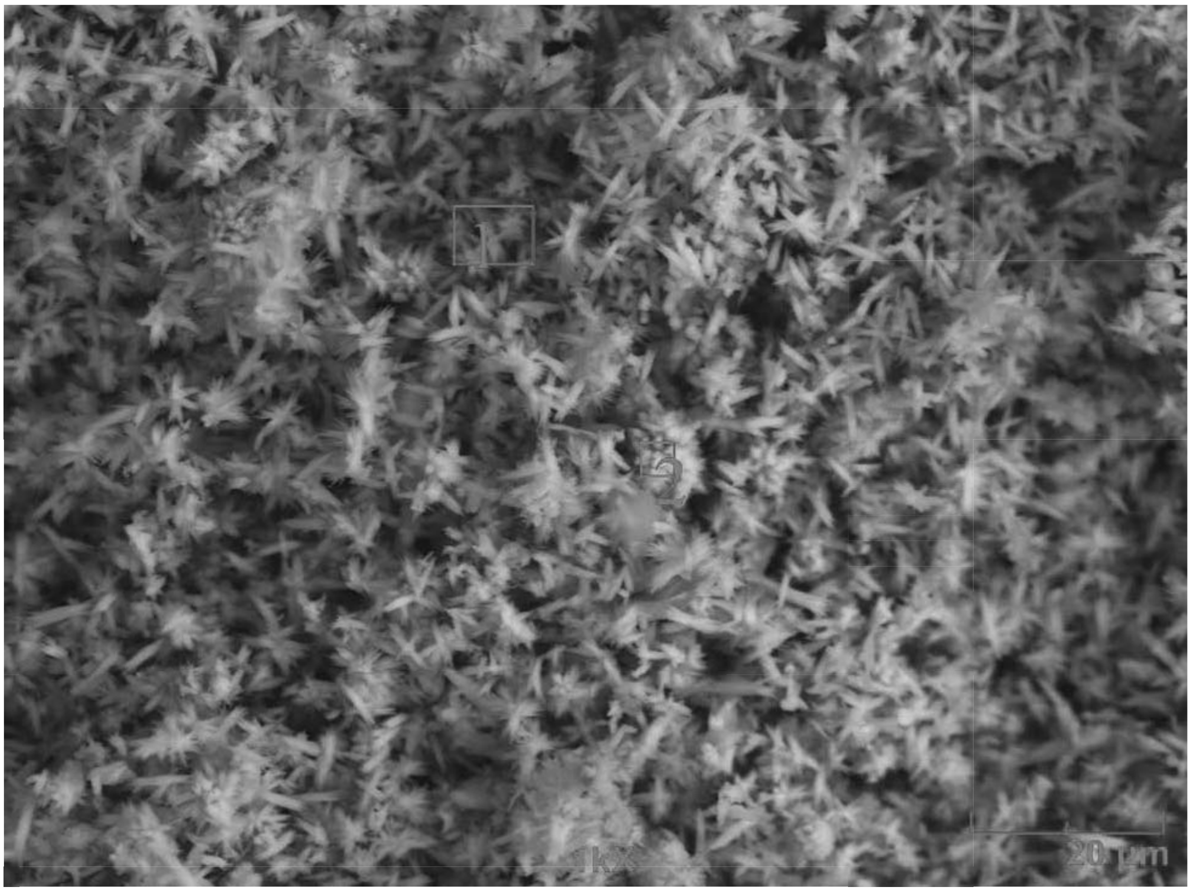


FIGURE 64
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 63

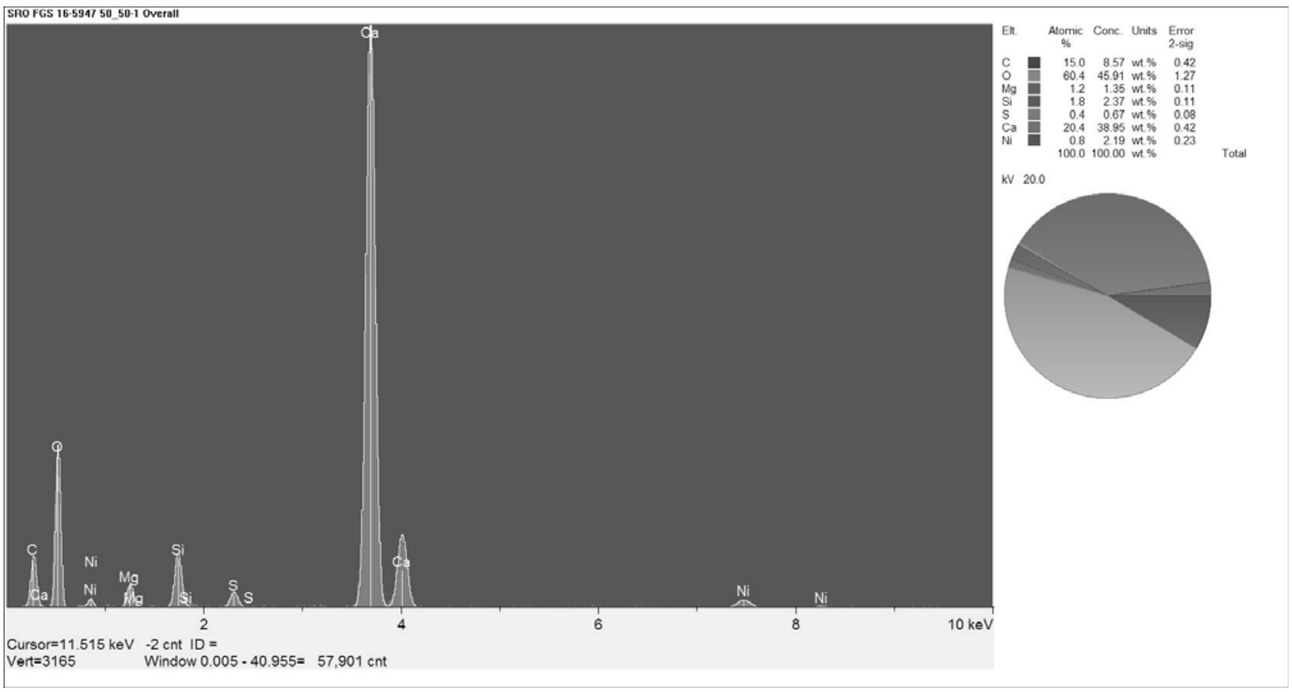


FIGURE 65
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 63

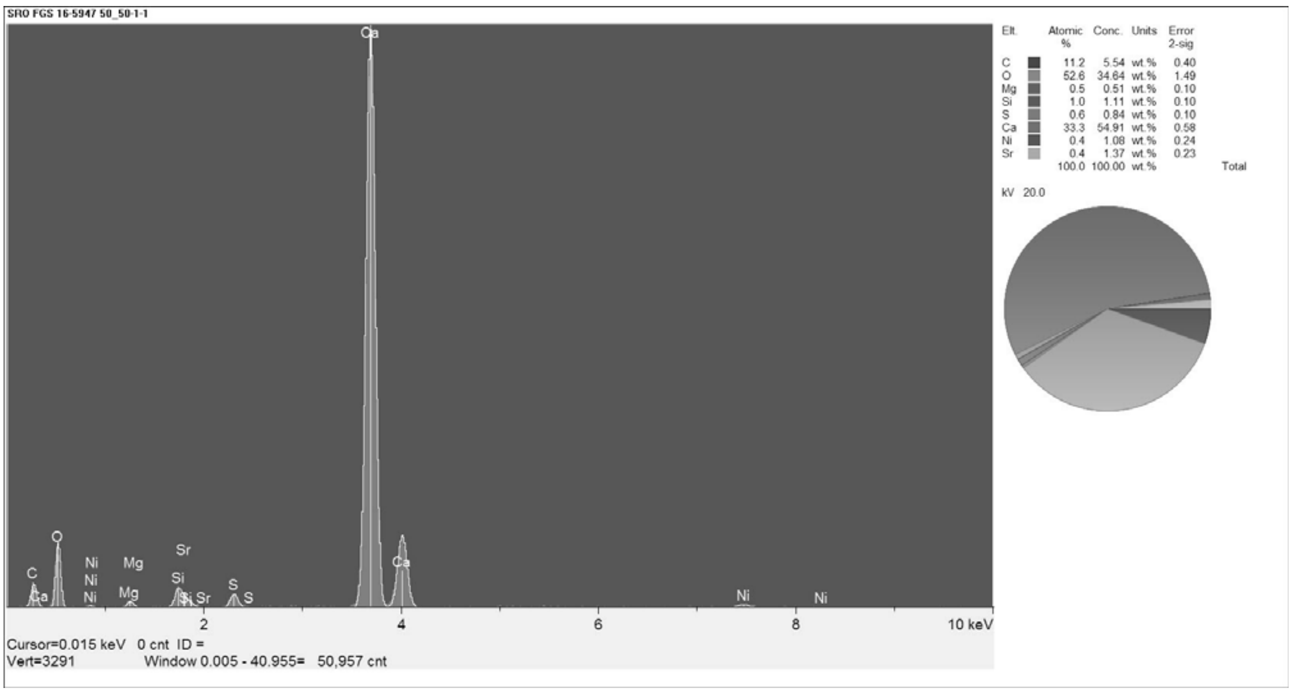


FIGURE 66
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 63

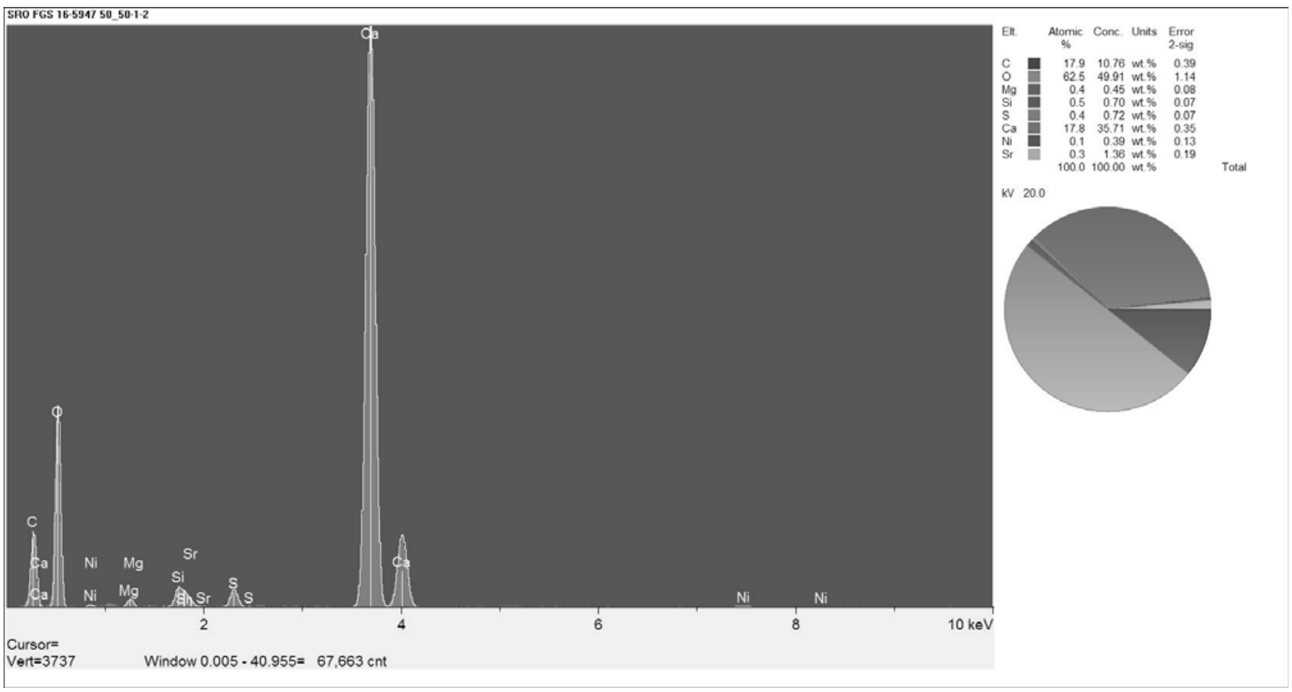


FIGURE 67
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE

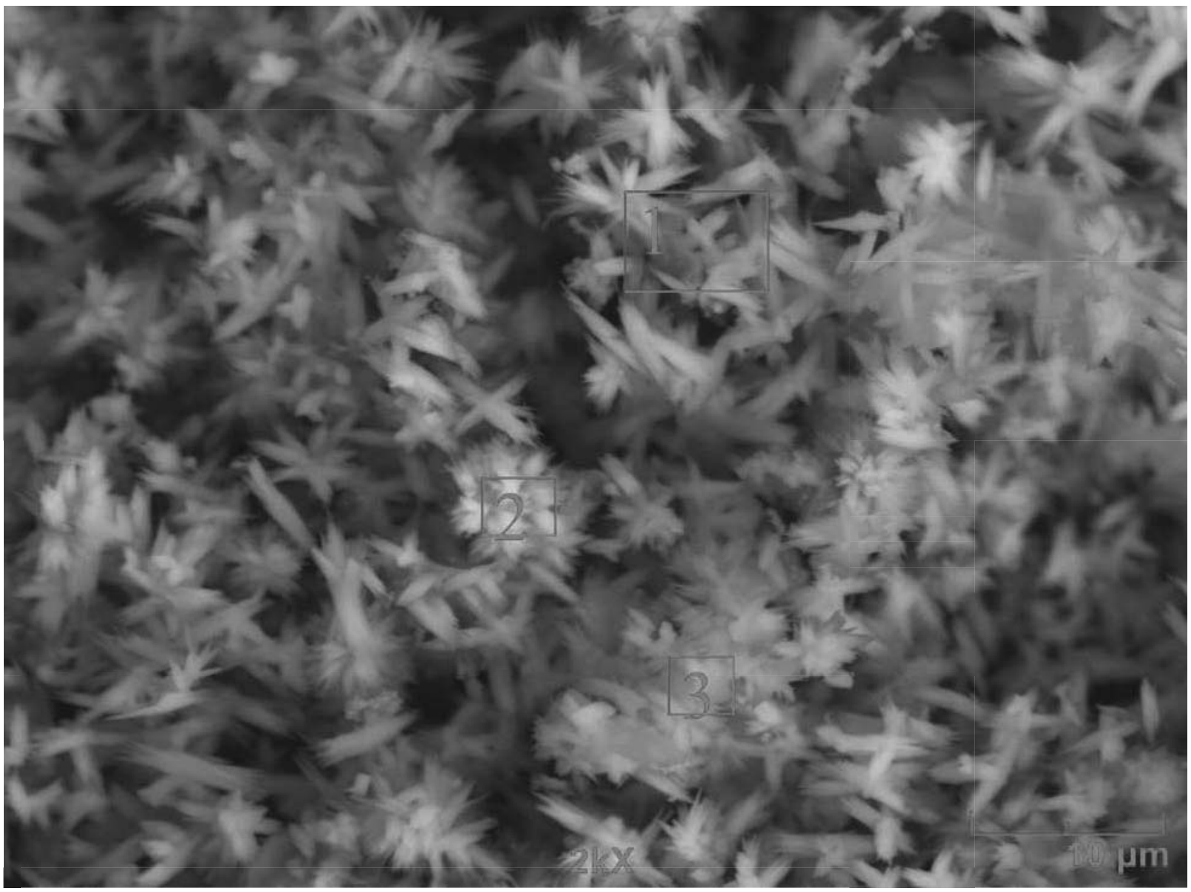
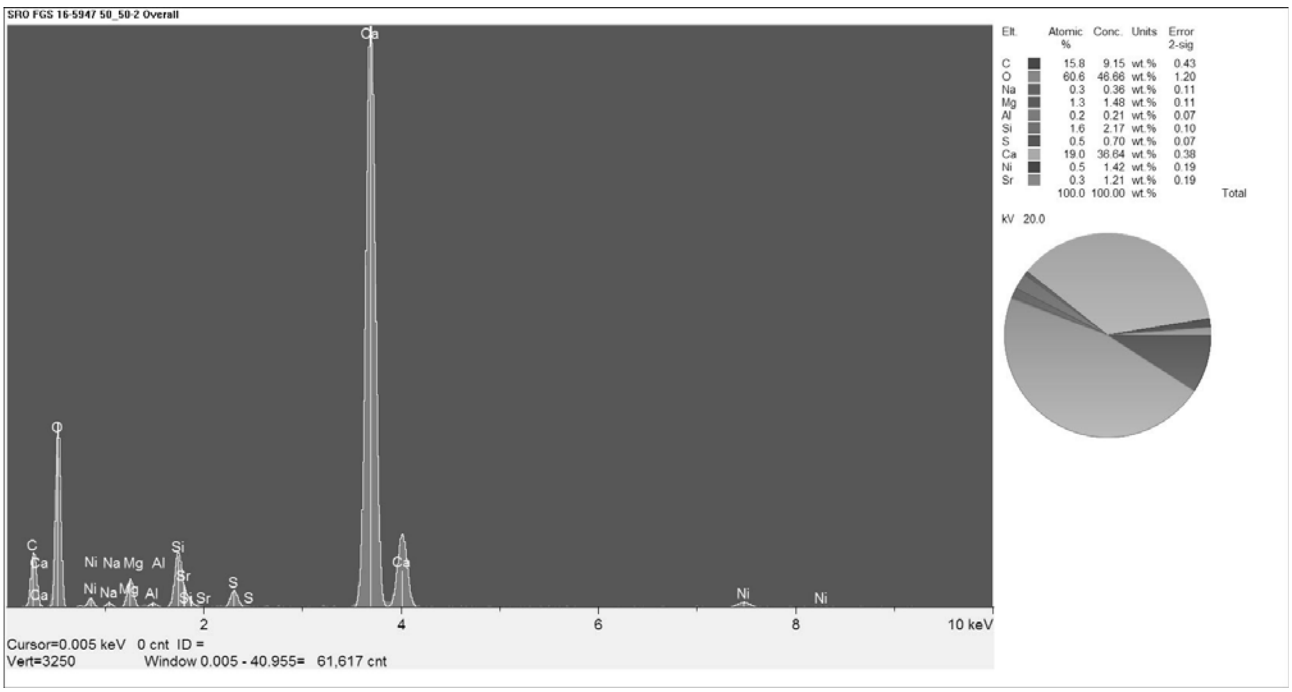


FIGURE 68
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 67



Elt.	Atomic %	Conc.	Units	Error 2-sig	
C	15.8	9.15	wt.%	0.43	
O	60.6	46.66	wt.%	1.20	
Na	0.3	0.36	wt.%	0.11	
Mg	1.3	1.48	wt.%	0.11	
Al	0.2	0.21	wt.%	0.07	
Si	1.6	2.17	wt.%	0.10	
S	0.5	0.70	wt.%	0.07	
Ca	19.0	36.64	wt.%	0.38	
Ni	0.5	1.42	wt.%	0.19	
Sr	0.3	1.21	wt.%	0.19	
	100.0	100.00	wt.%		Total

FIGURE 69
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 67

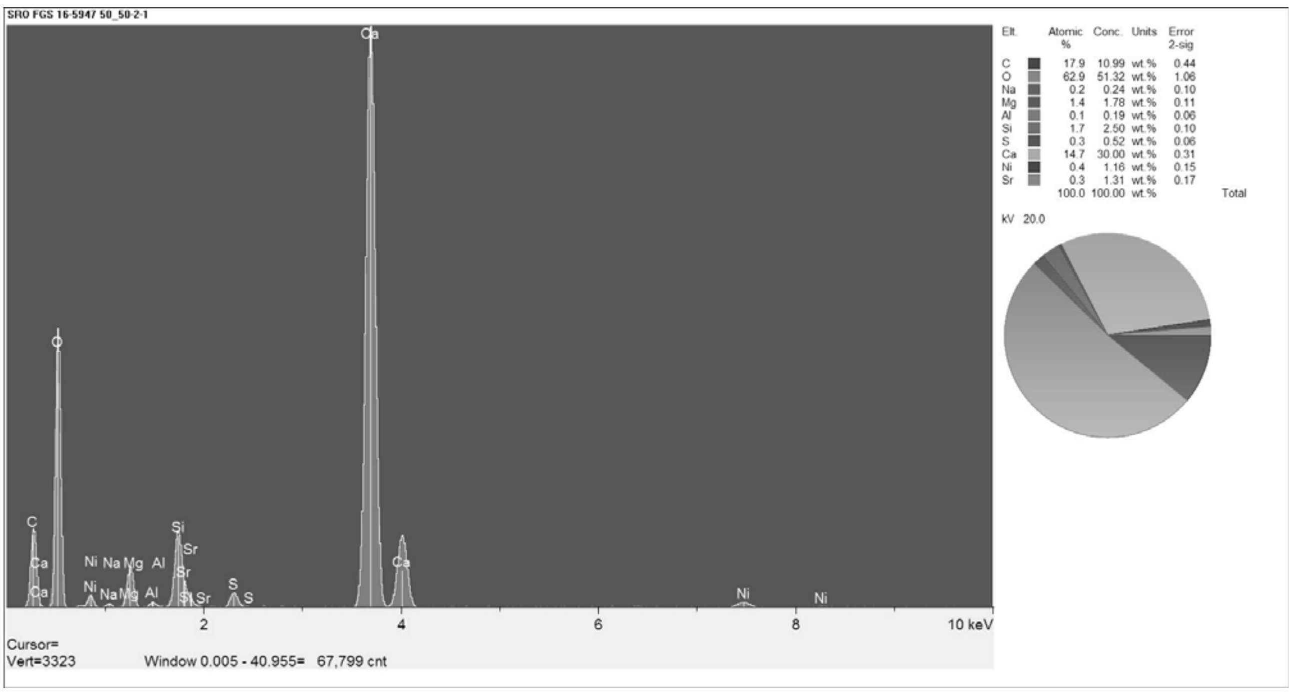


FIGURE 70
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 67

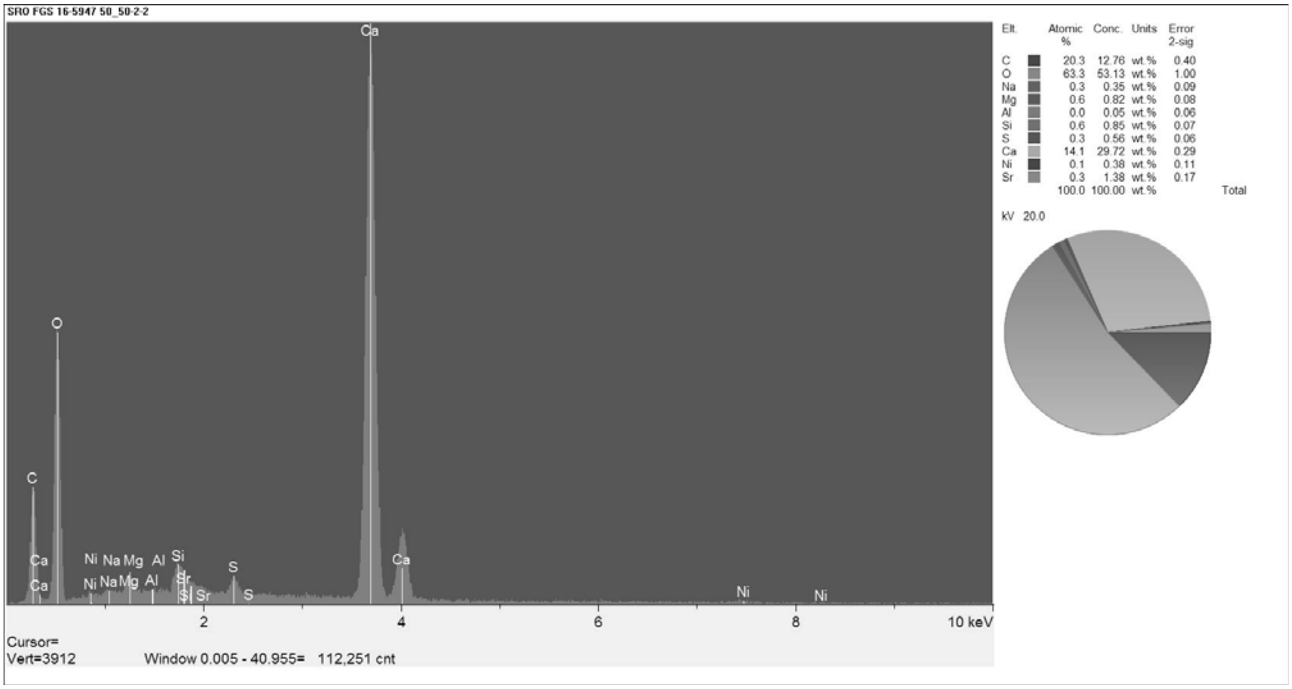


FIGURE 71
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #3 IN FIGURE 67

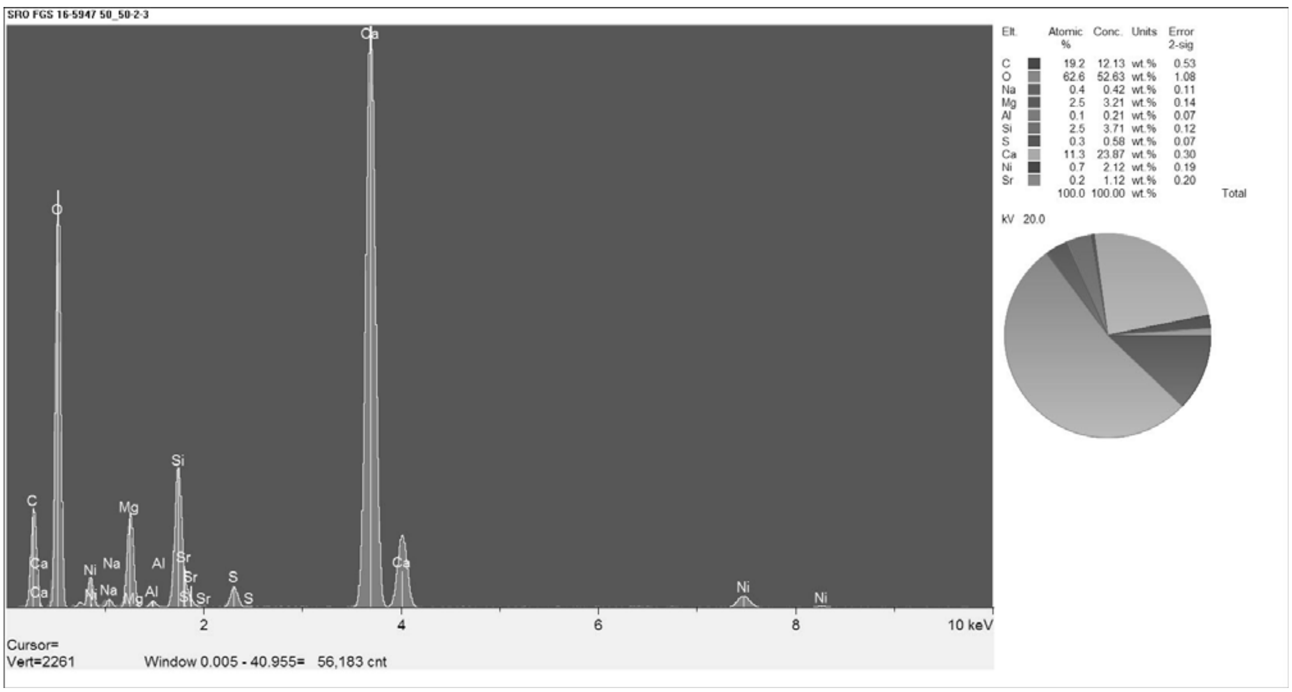


FIGURE 72
PHOTOGRAPH OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE

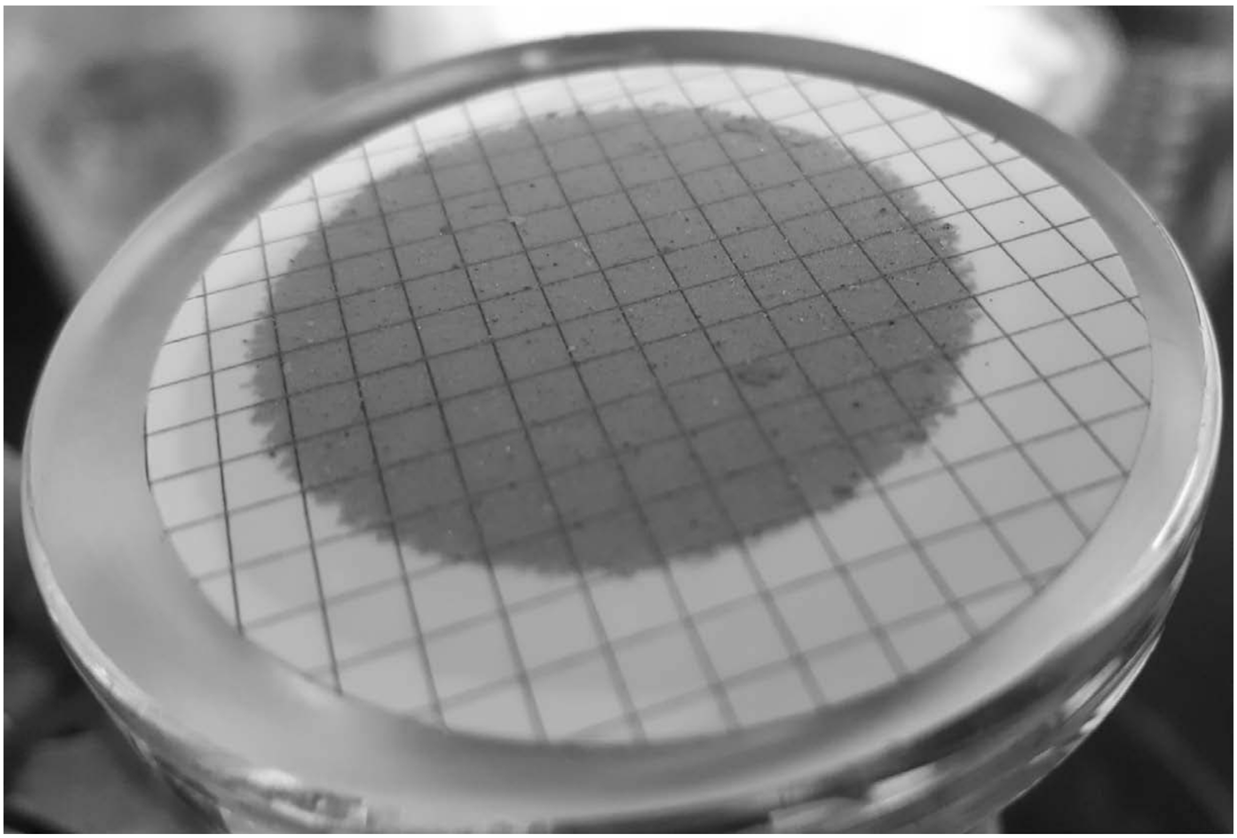


FIGURE 73
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE

FIGURE 74
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 73

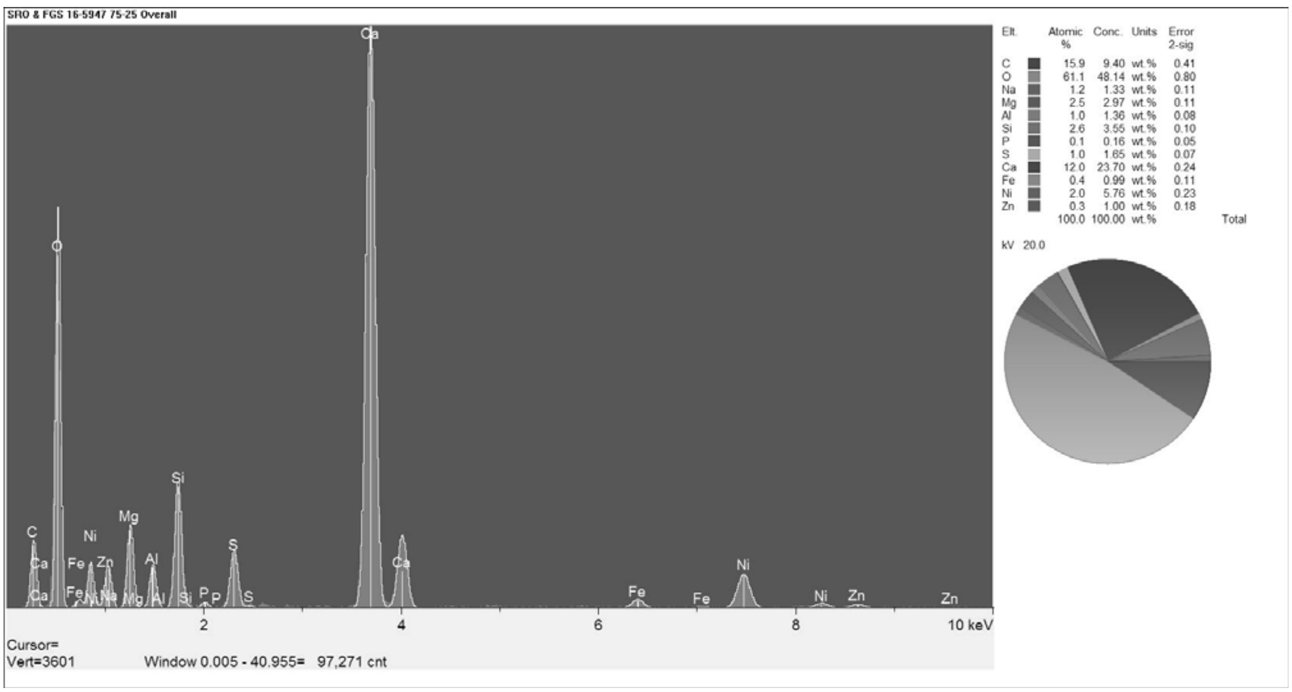


FIGURE 75

EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 73

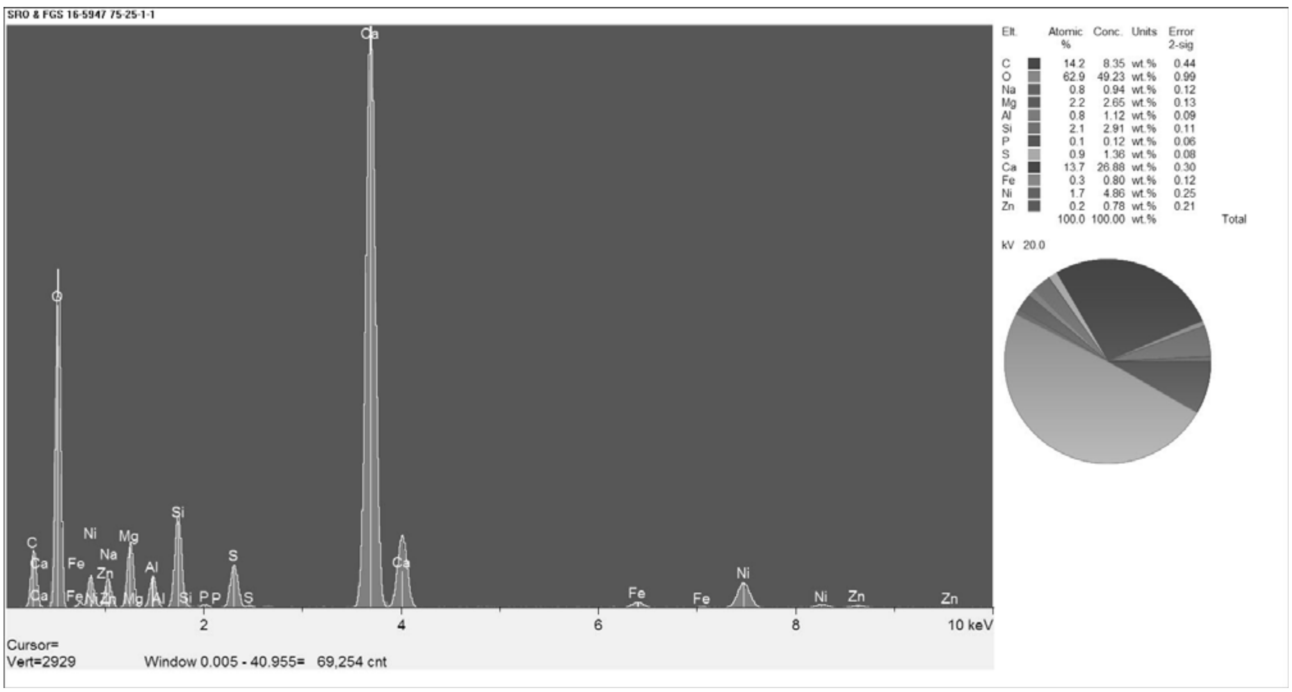


FIGURE 76
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 73

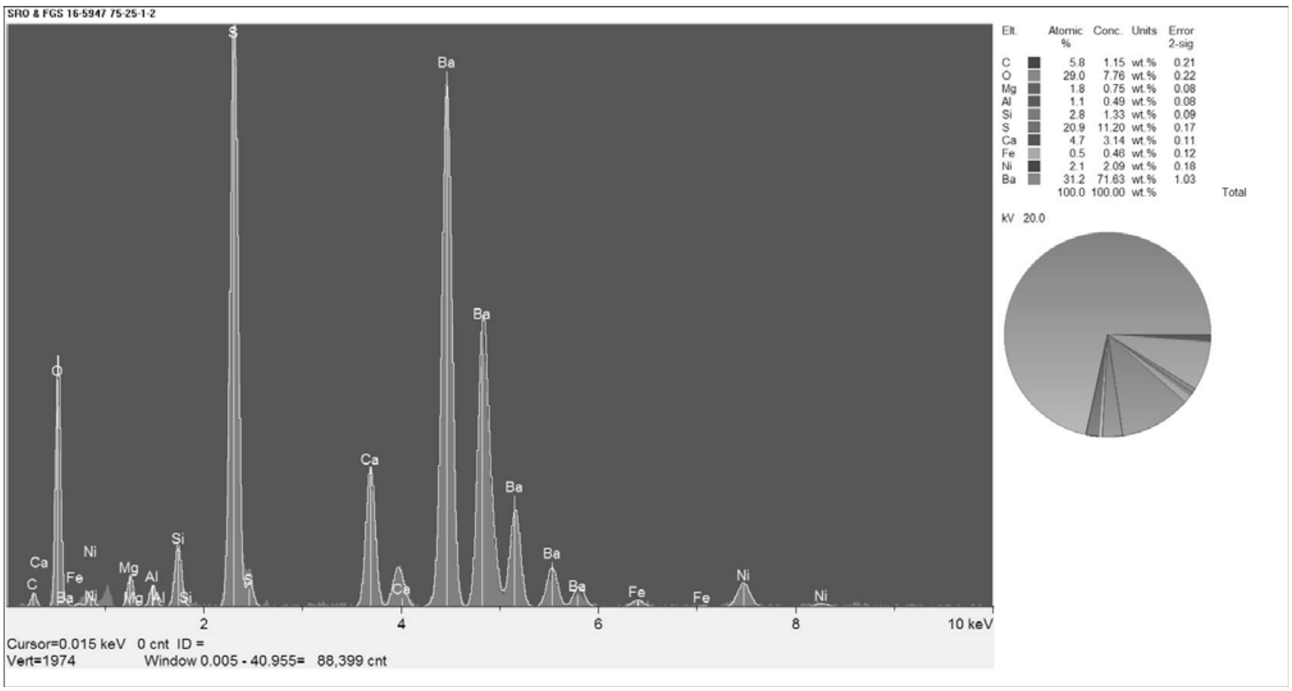


FIGURE 77
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE

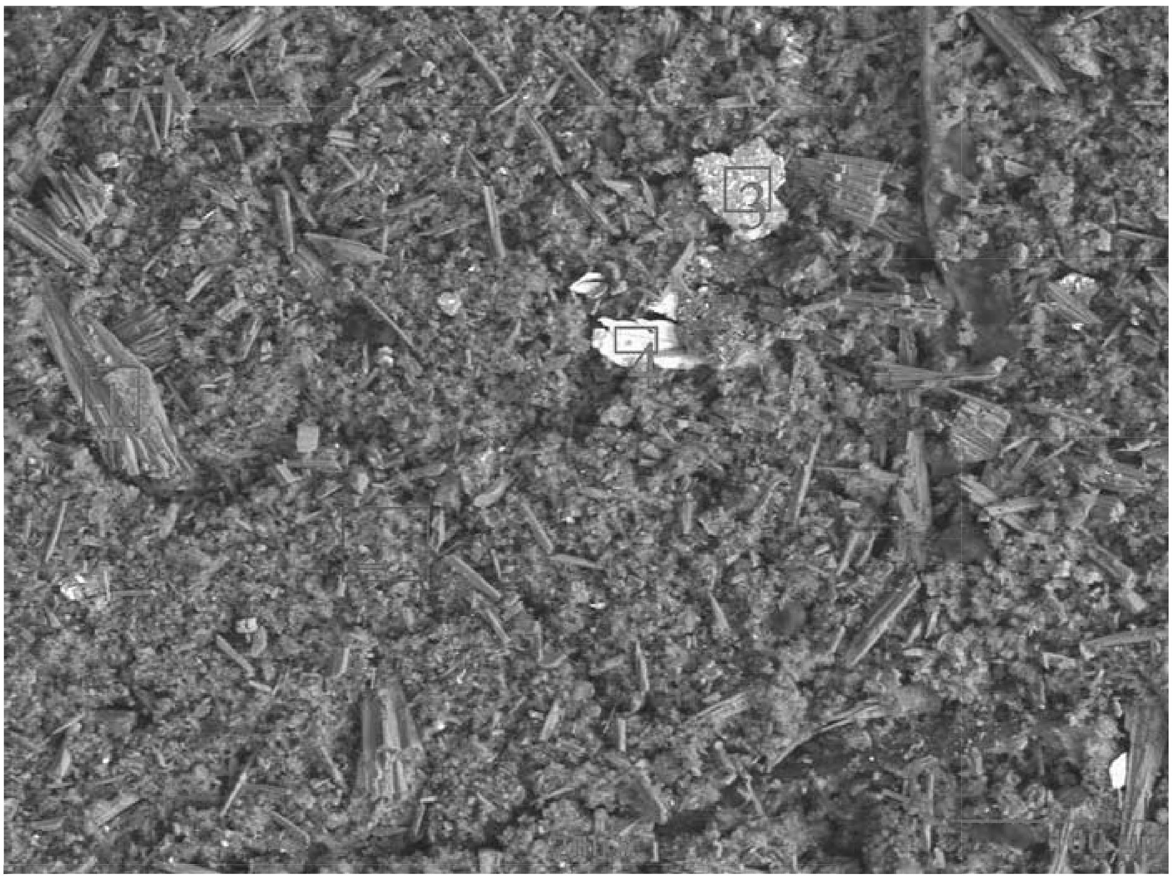


FIGURE 78
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 77

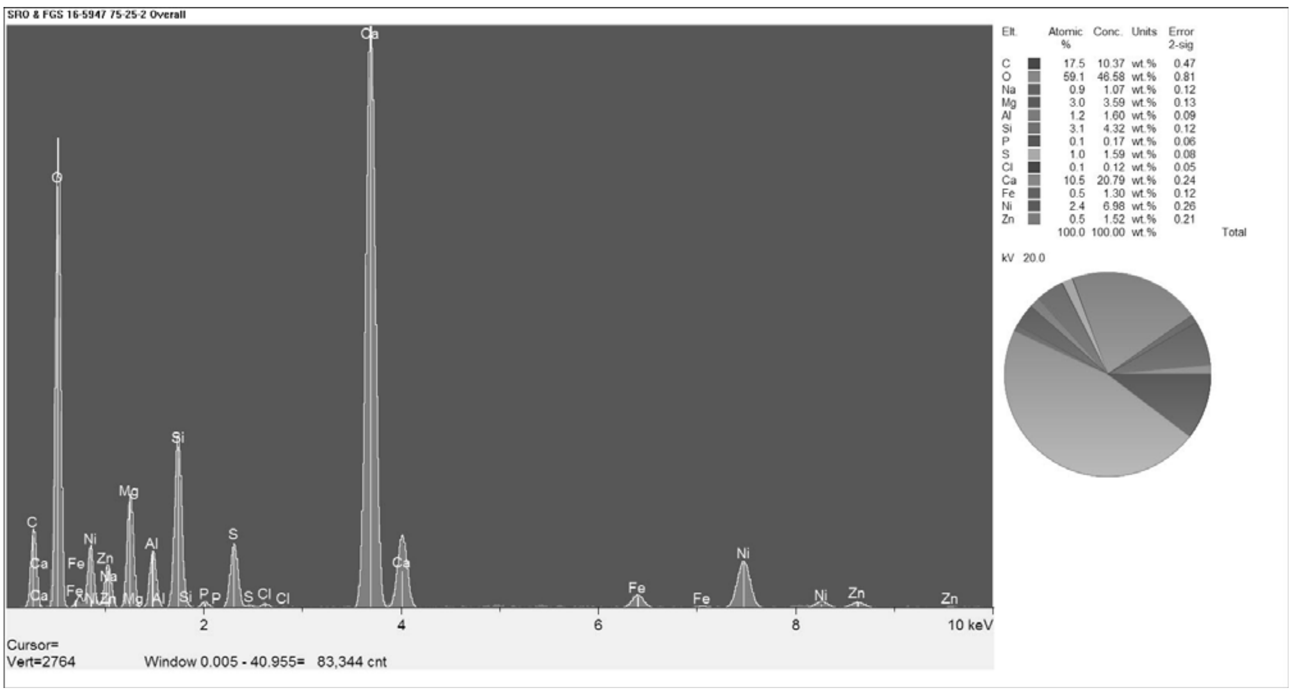


FIGURE 79
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 77

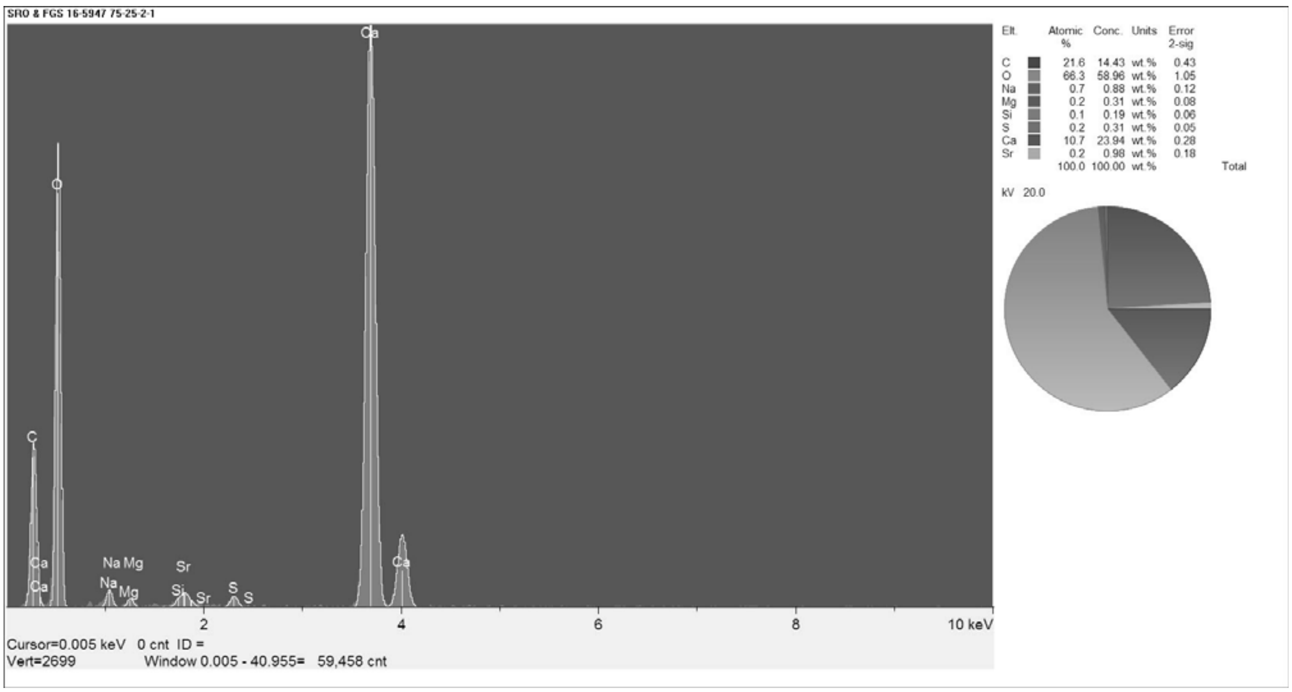


FIGURE 80
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 77

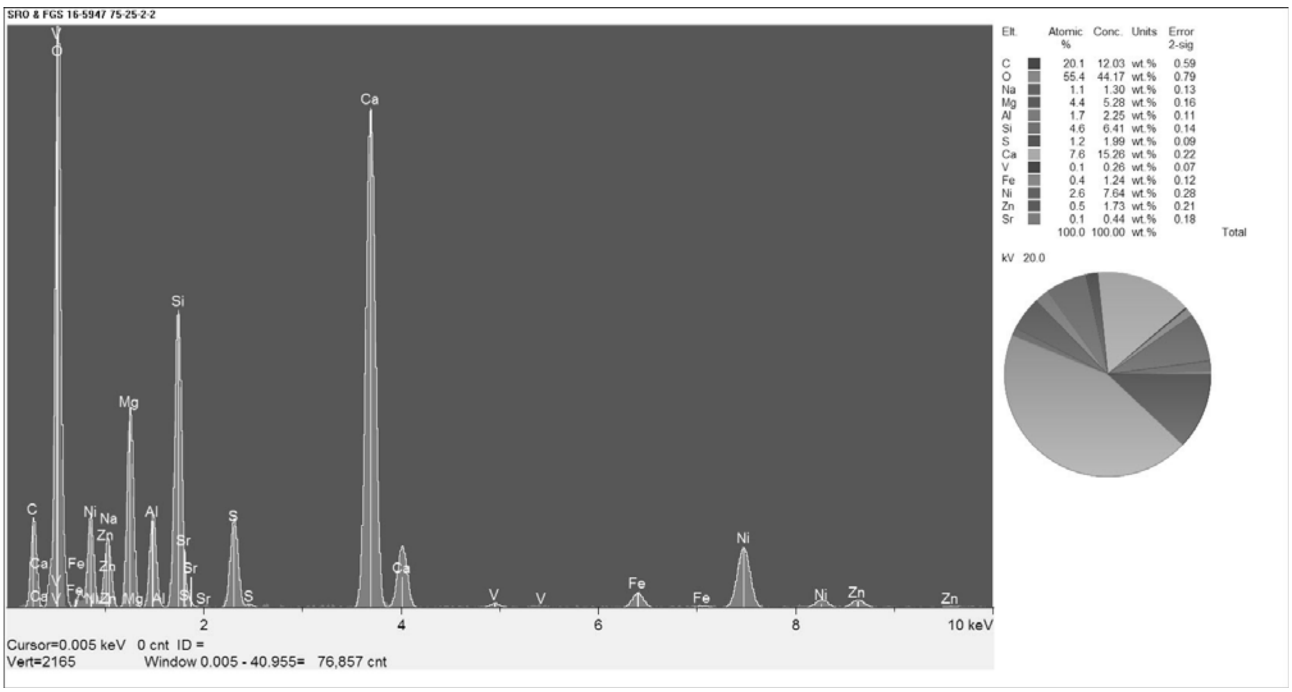


FIGURE 81
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #3 IN FIGURE 77

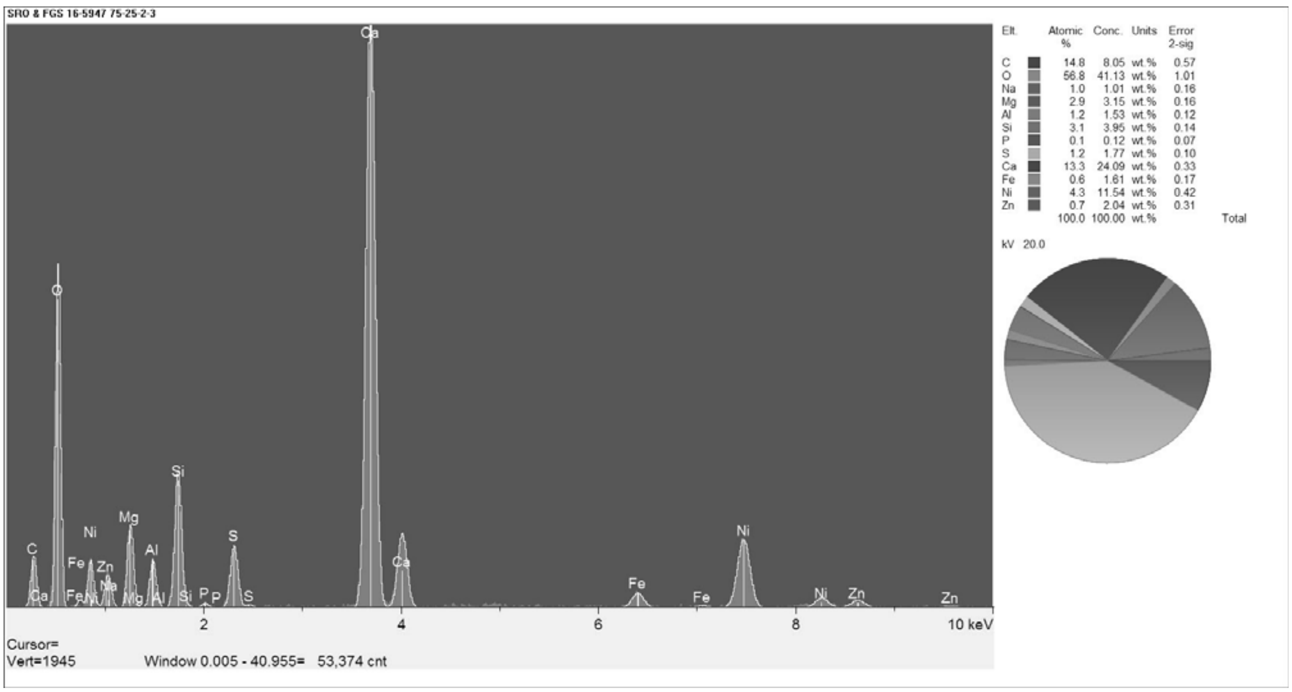


FIGURE 82
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:FGS SAMPLE PRECIPITATE PARTICLES LABELED #4 IN FIGURE 77

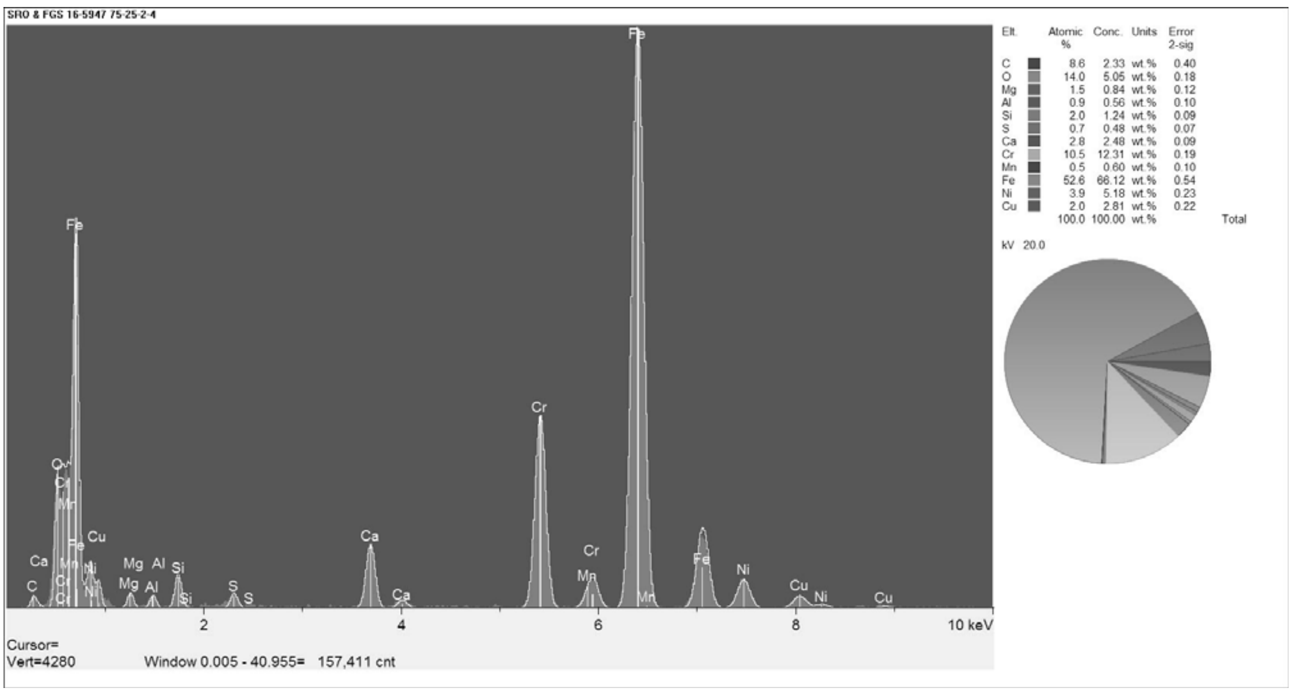


FIGURE 83
PHOTOGRAPH OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE

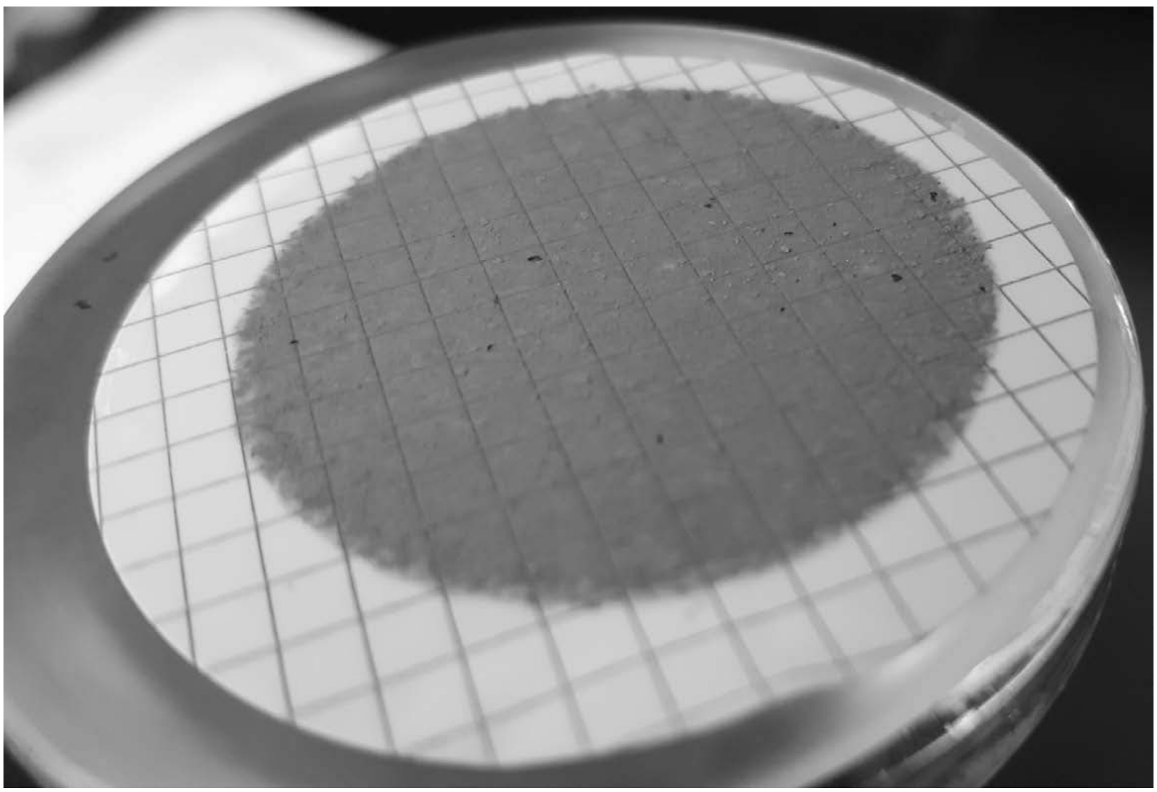


FIGURE 84
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE

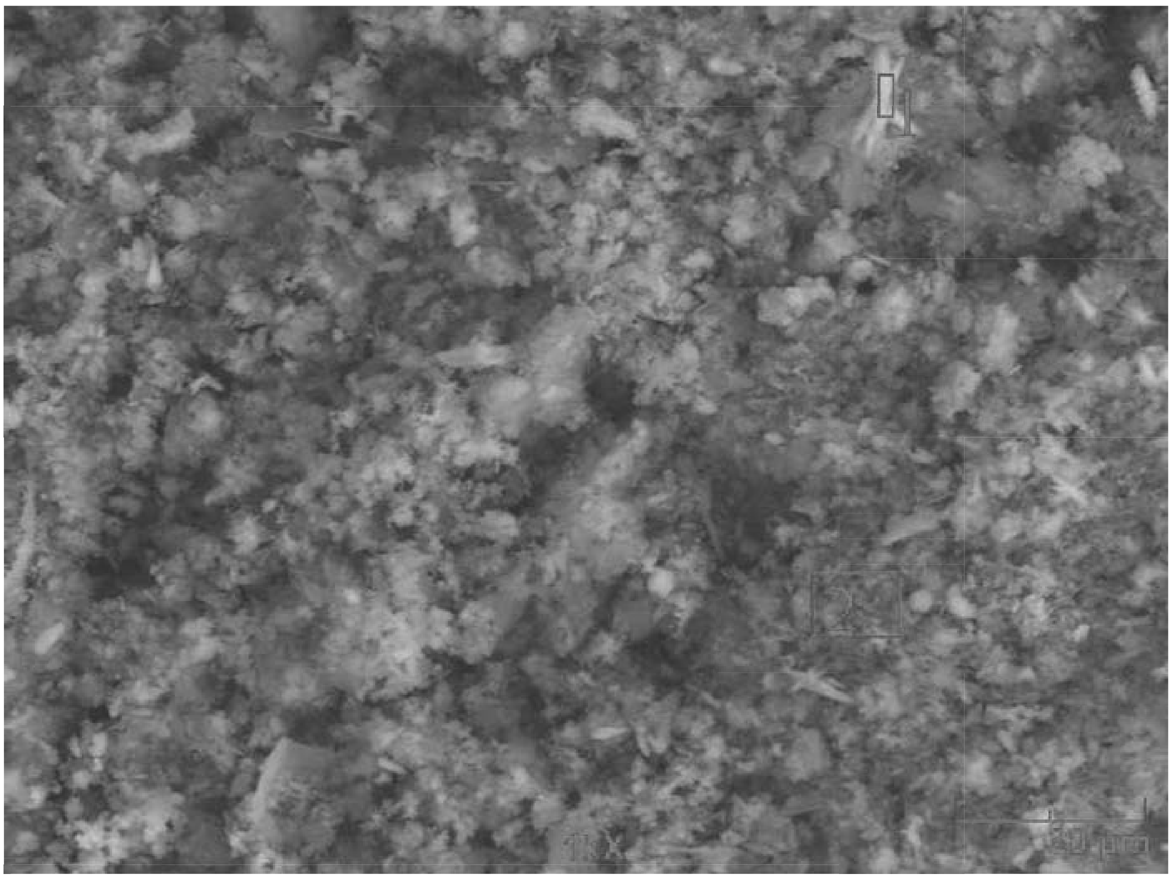


FIGURE 85
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 84

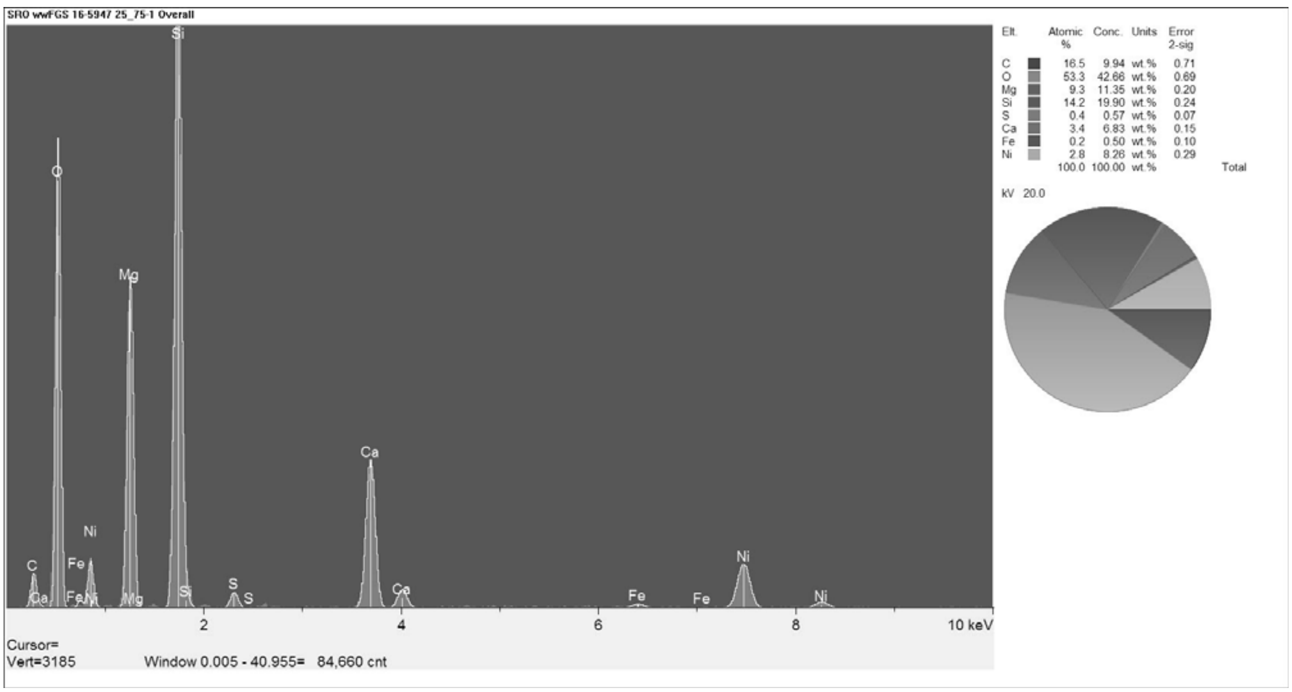


FIGURE 86
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 84

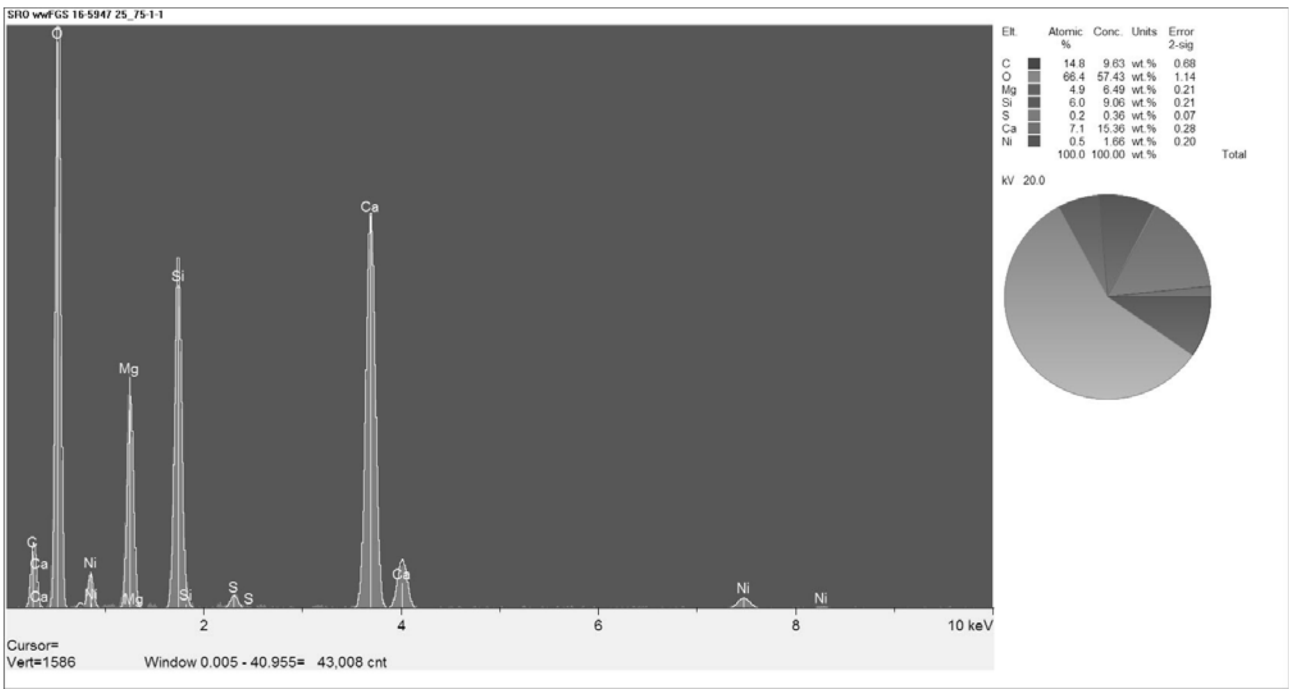


FIGURE 87
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 84

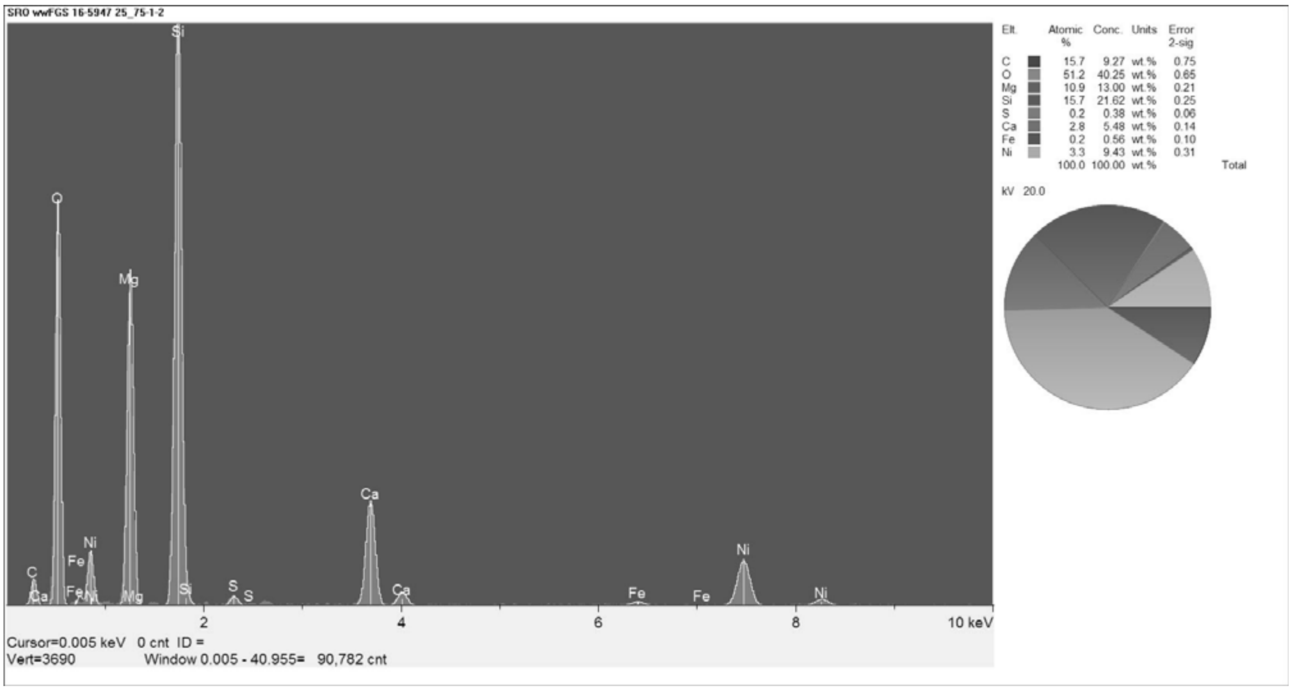


FIGURE 88
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE

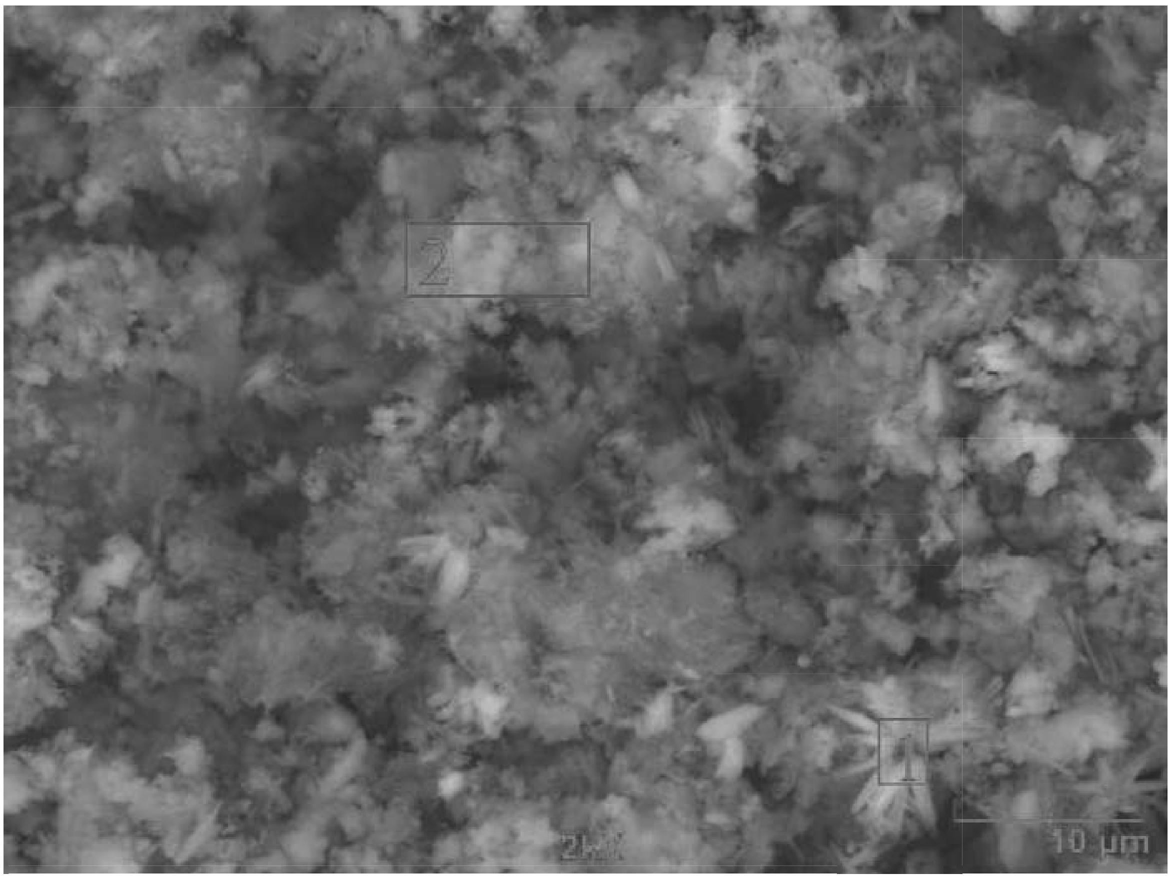


FIGURE 89
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 88

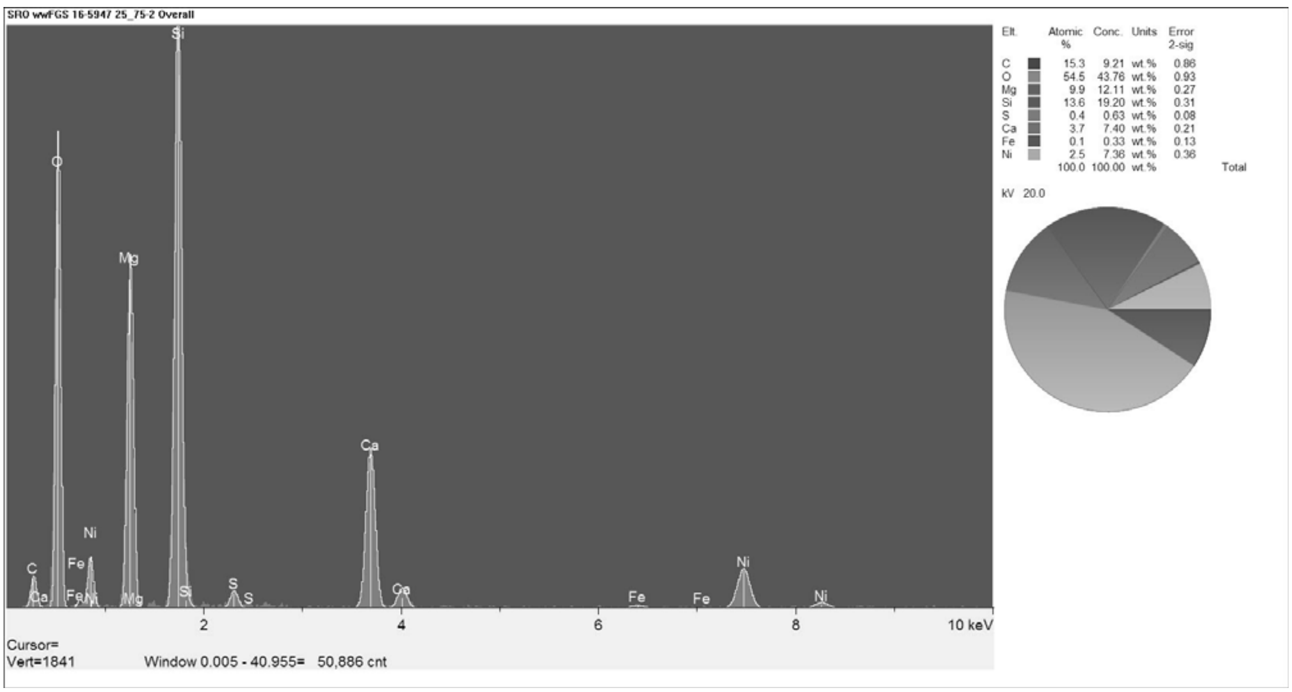


FIGURE 90
EDS MICROCHEMICAL ANALYSIS OF THE 25:75 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 88

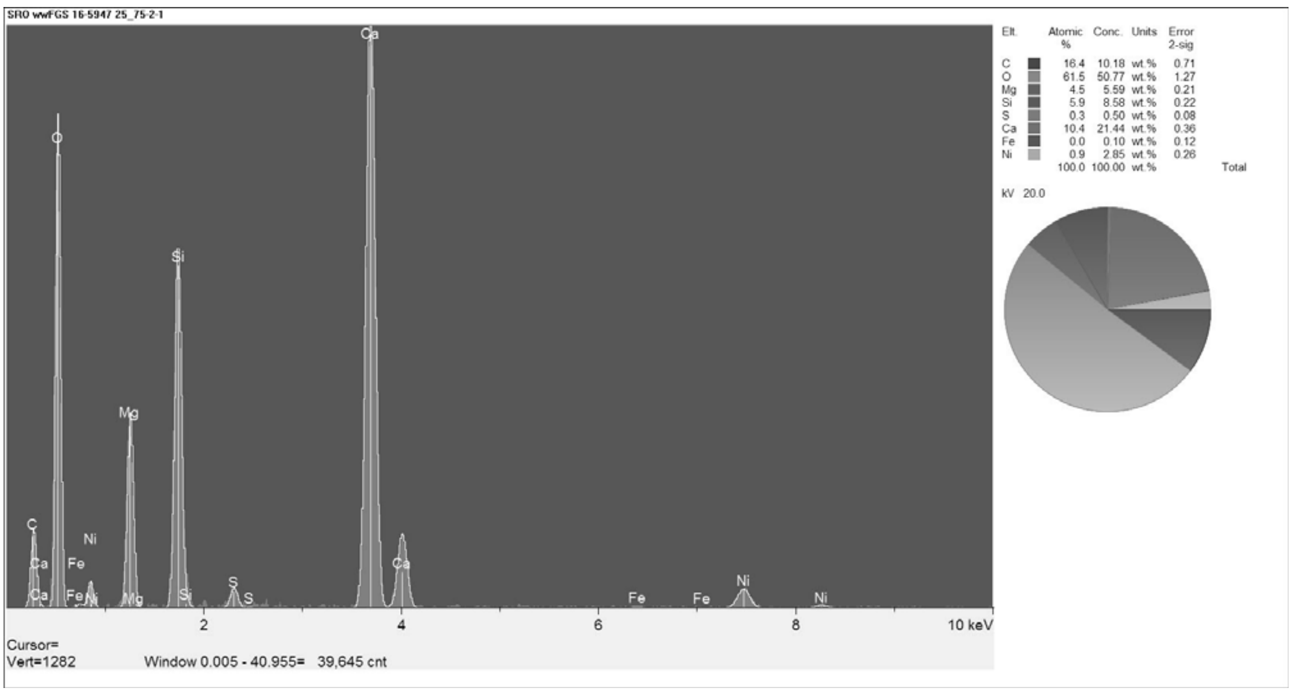


FIGURE 91
PHOTOGRAPH OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE

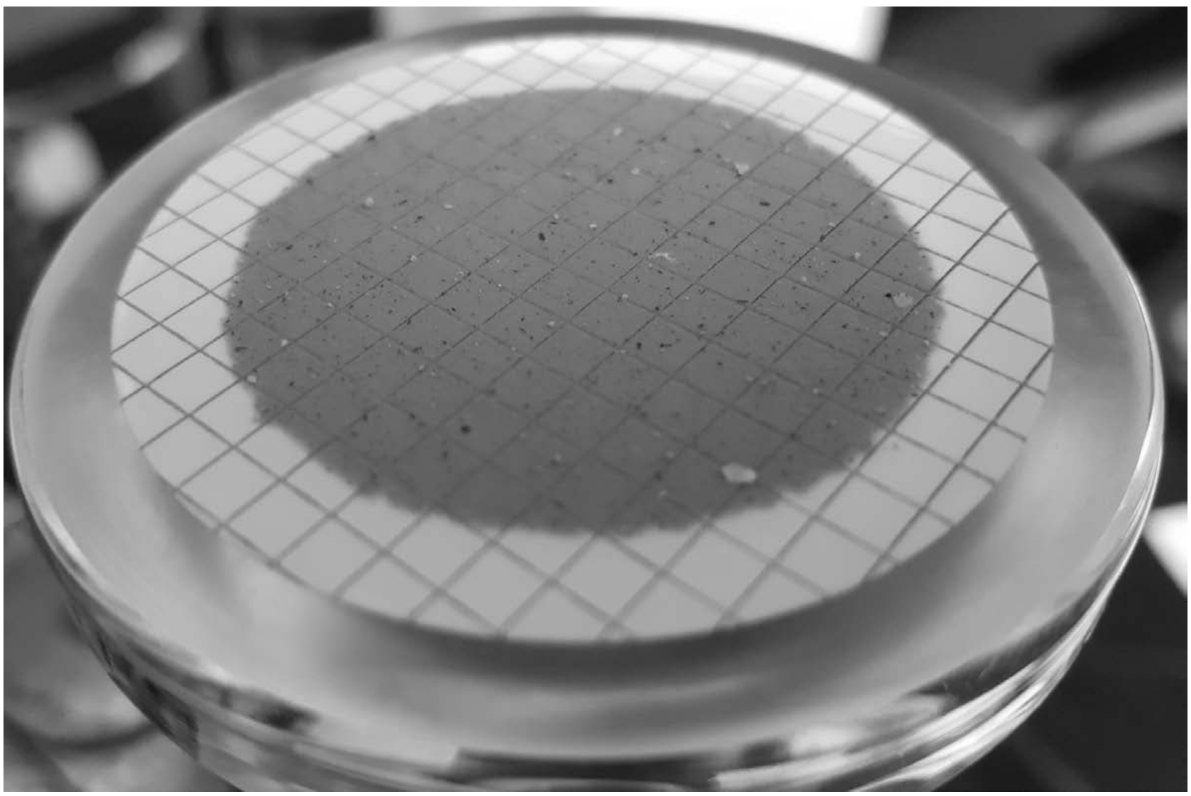


FIGURE 92
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE

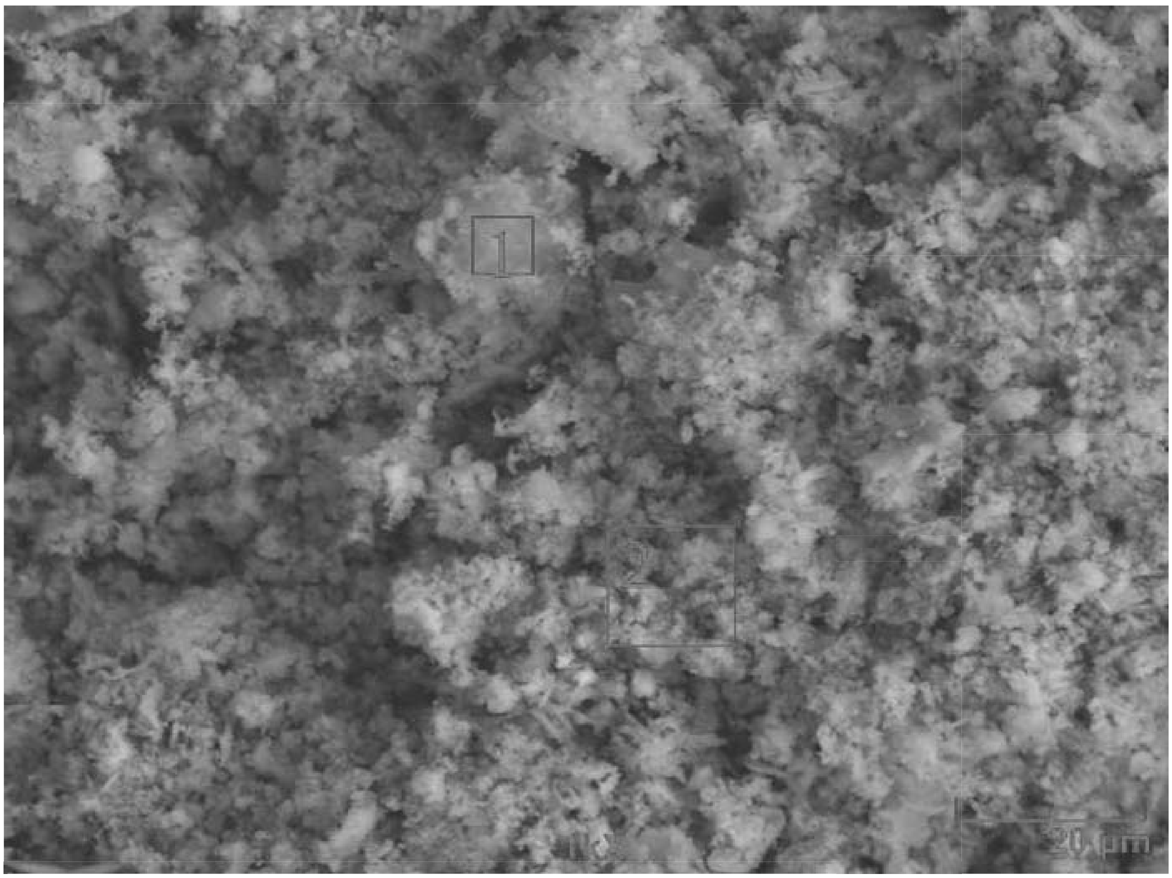


FIGURE 93
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 92

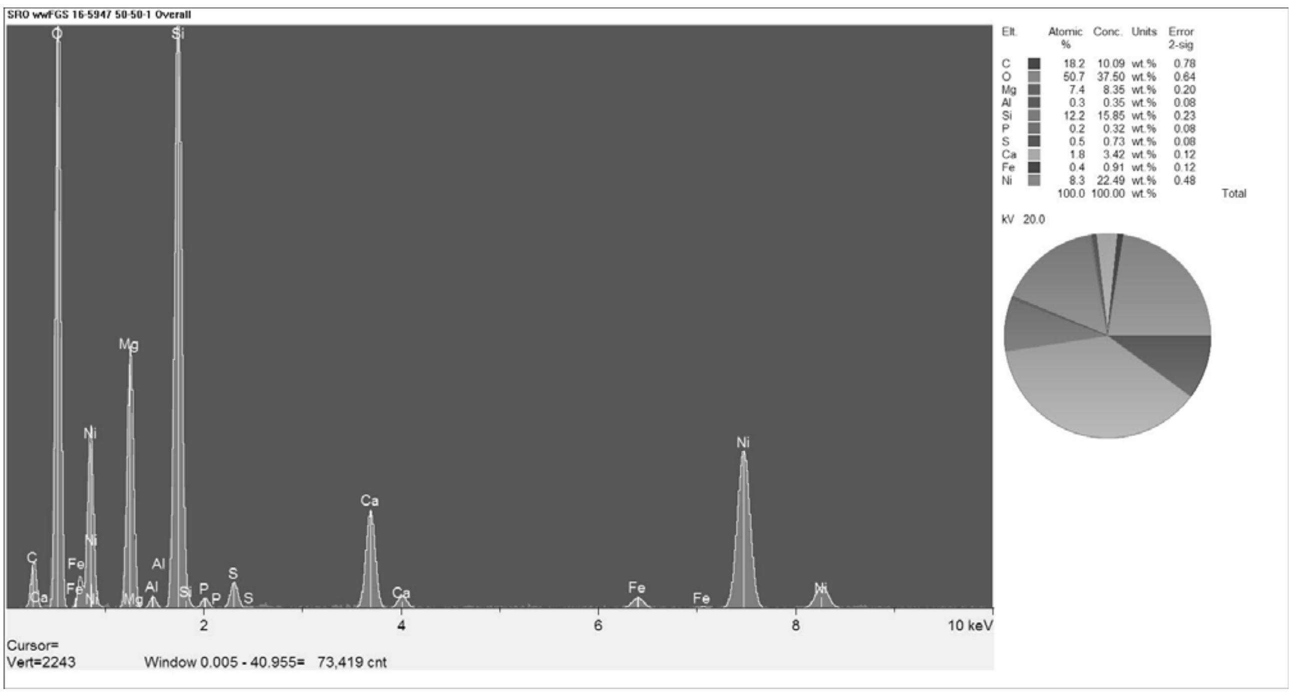


FIGURE 94

EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 92

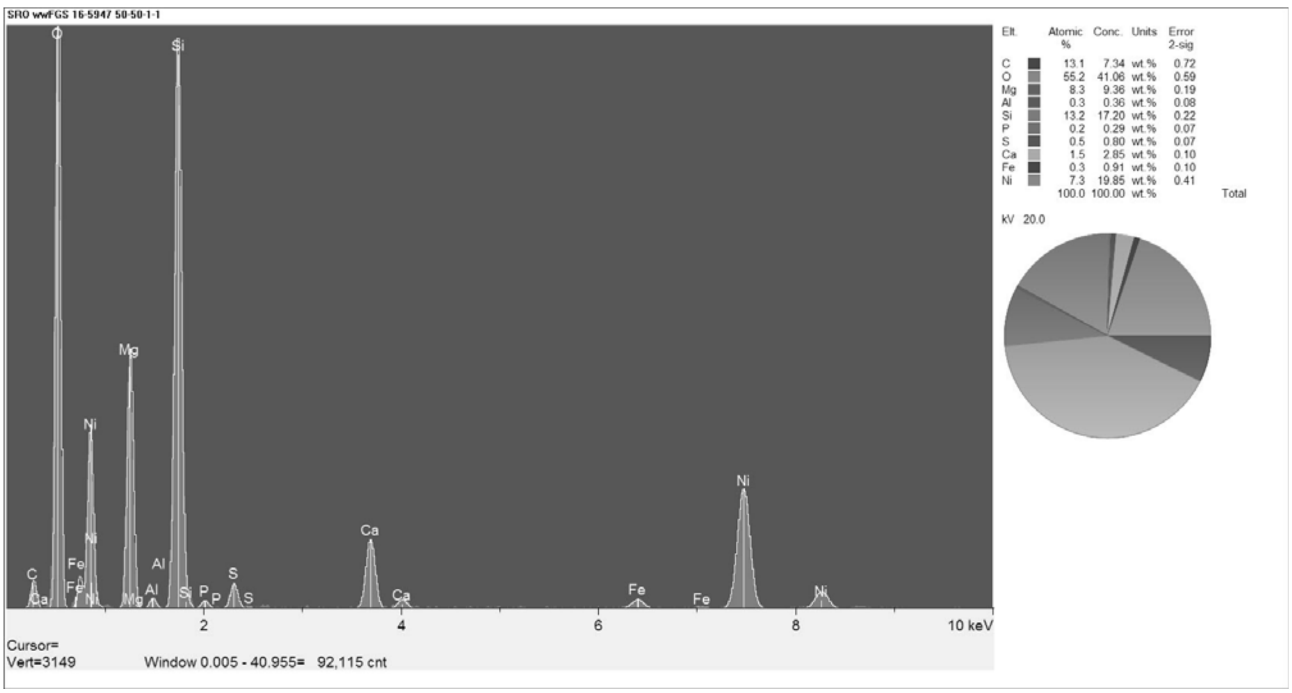


FIGURE 95
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 92

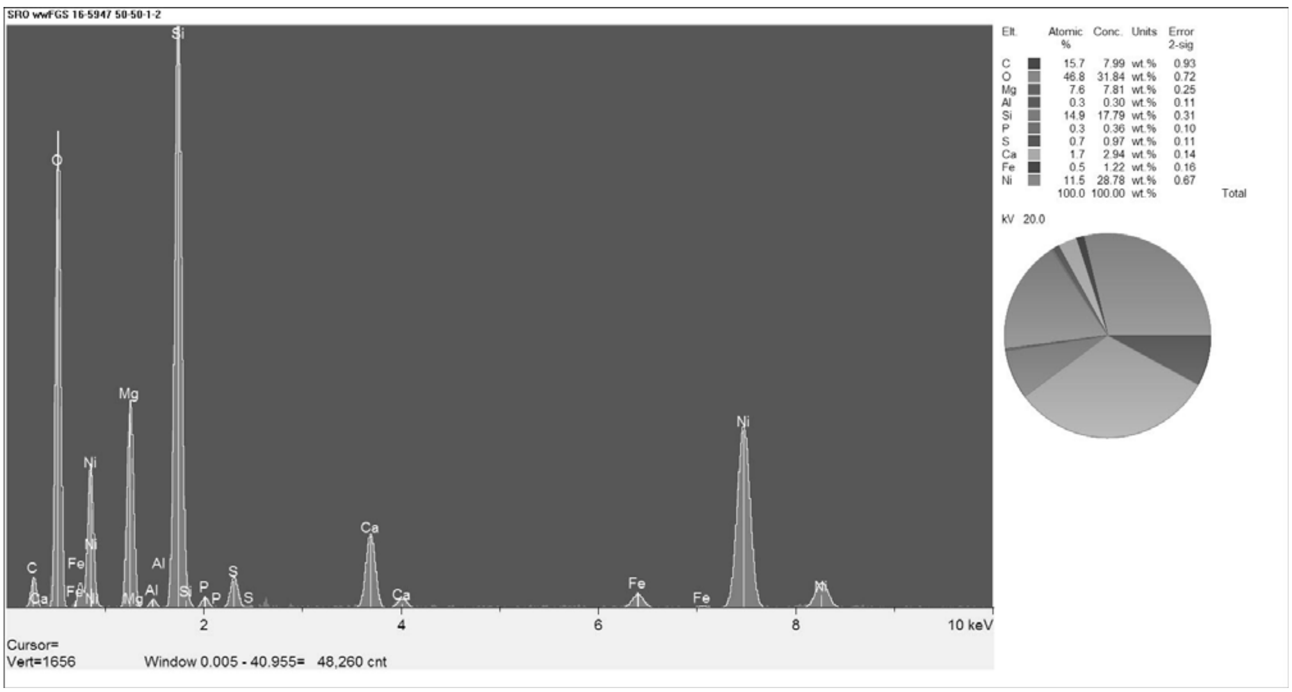


FIGURE 96
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE

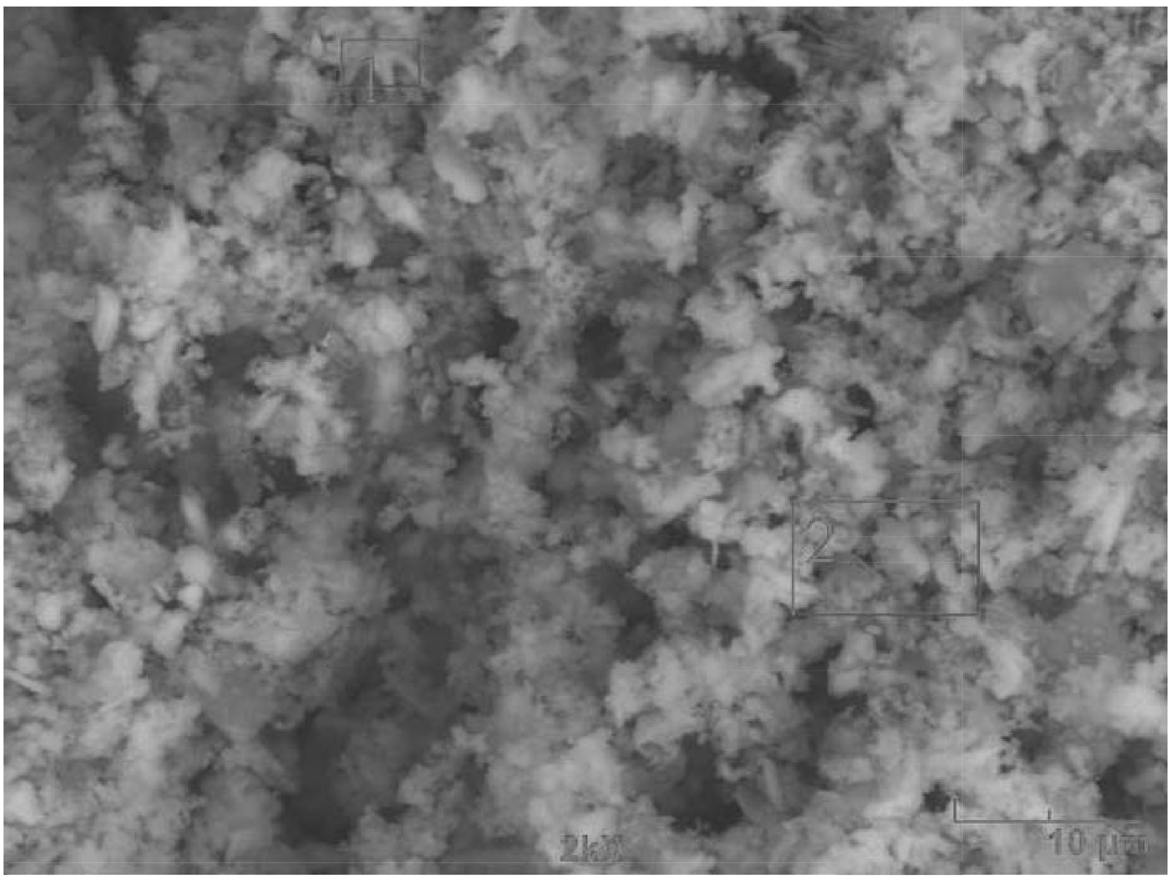
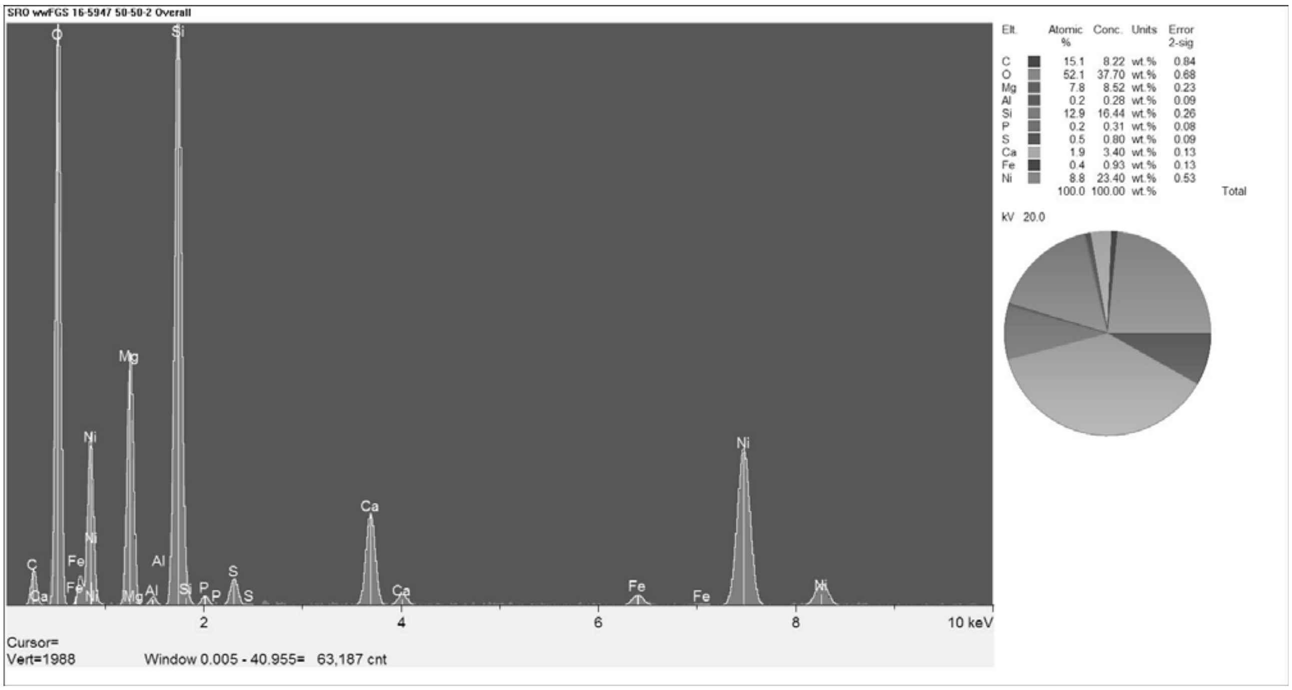


FIGURE 97
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 96



Elt.		Atomic %	Conc.	Units	Error 2-sig	
C		15.1	8.22	wt.%	0.84	
O		52.1	37.70	wt.%	0.68	
Mg		7.8	8.52	wt.%	0.23	
Al		0.2	0.28	wt.%	0.09	
Si		12.9	16.44	wt.%	0.26	
P		0.2	0.31	wt.%	0.08	
S		0.5	0.80	wt.%	0.09	
Ca		1.9	3.40	wt.%	0.13	
Fe		0.4	0.93	wt.%	0.13	
Ni		8.8	23.40	wt.%	0.53	
		100.0	100.00	wt.%		Total

FIGURE 98
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 96

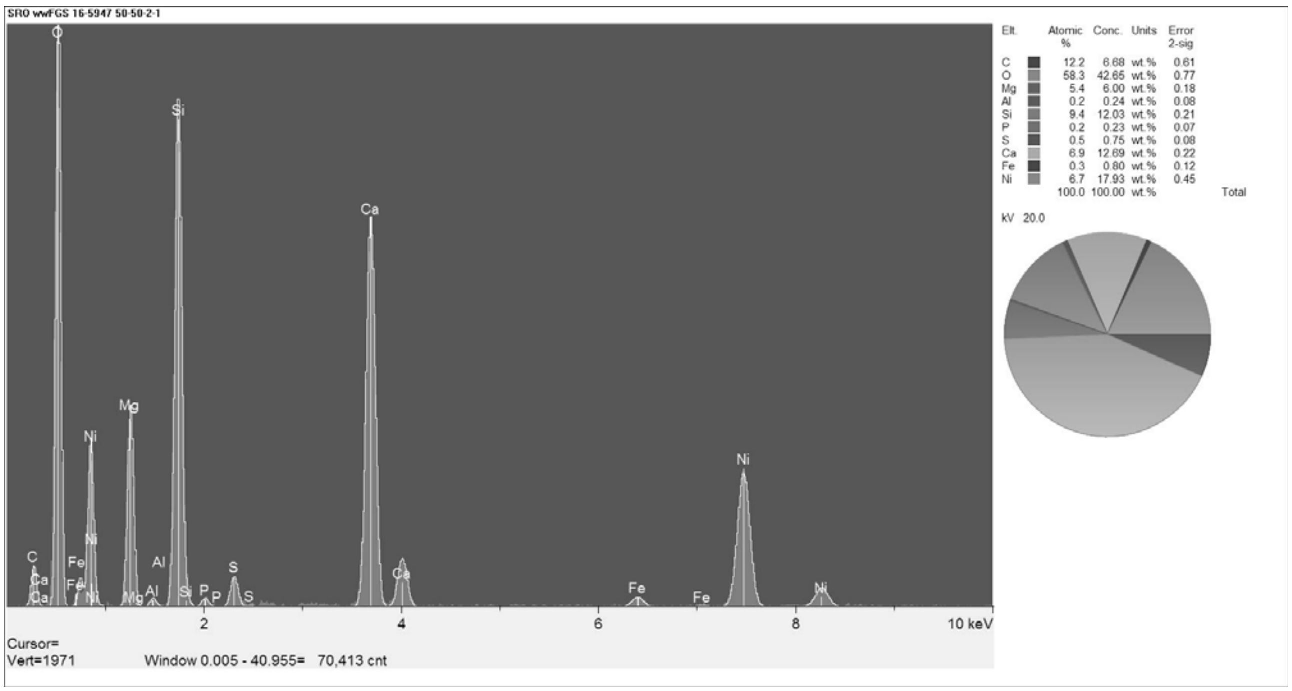


FIGURE 99
EDS MICROCHEMICAL ANALYSIS OF THE 50:50 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 96

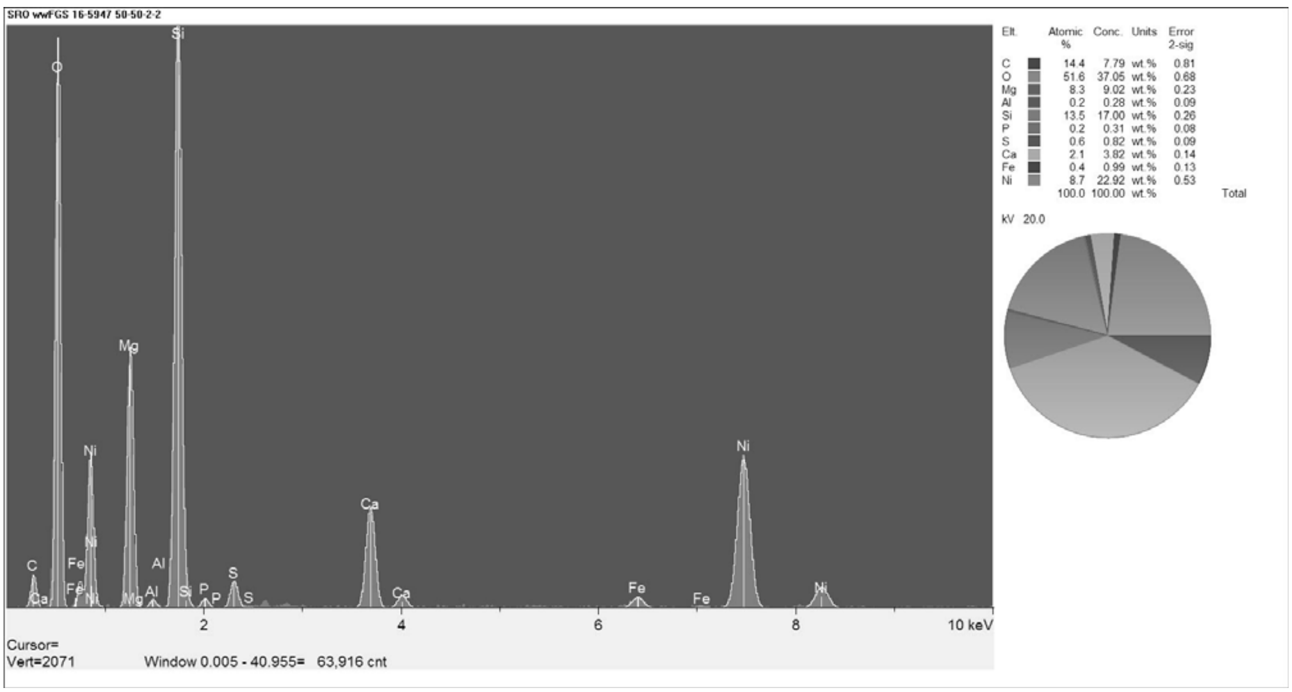


FIGURE 100
PHOTOGRAPH OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE
\

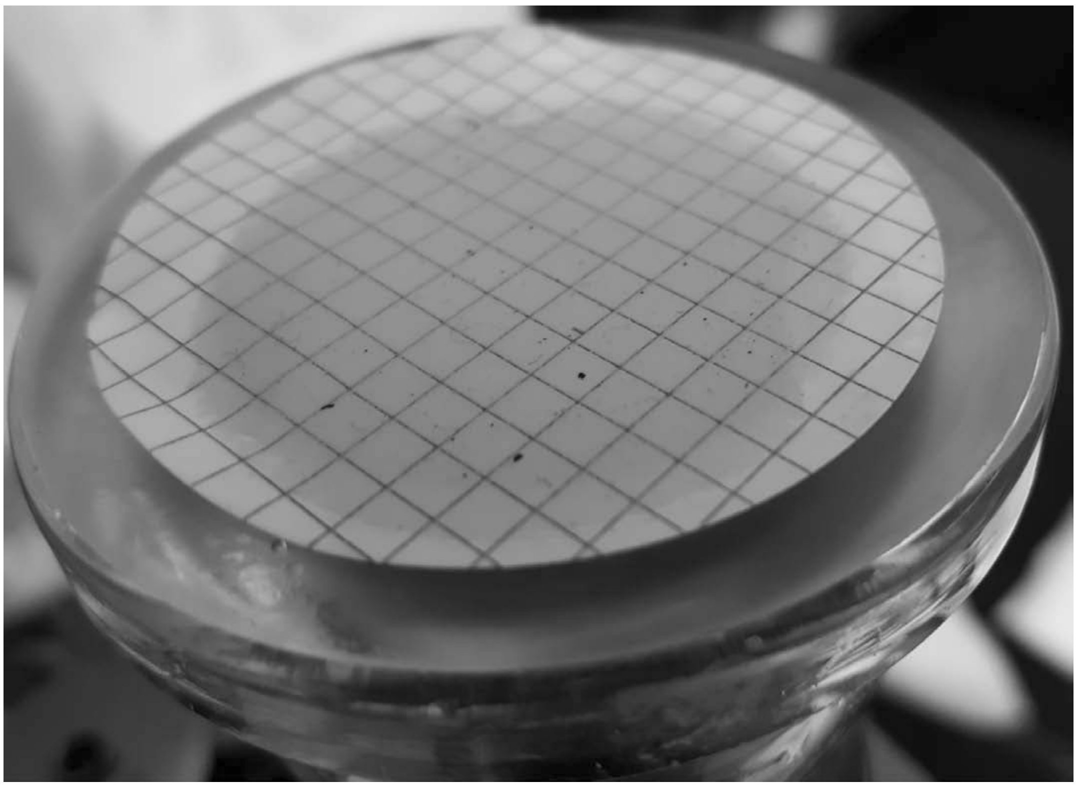


FIGURE 101
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE

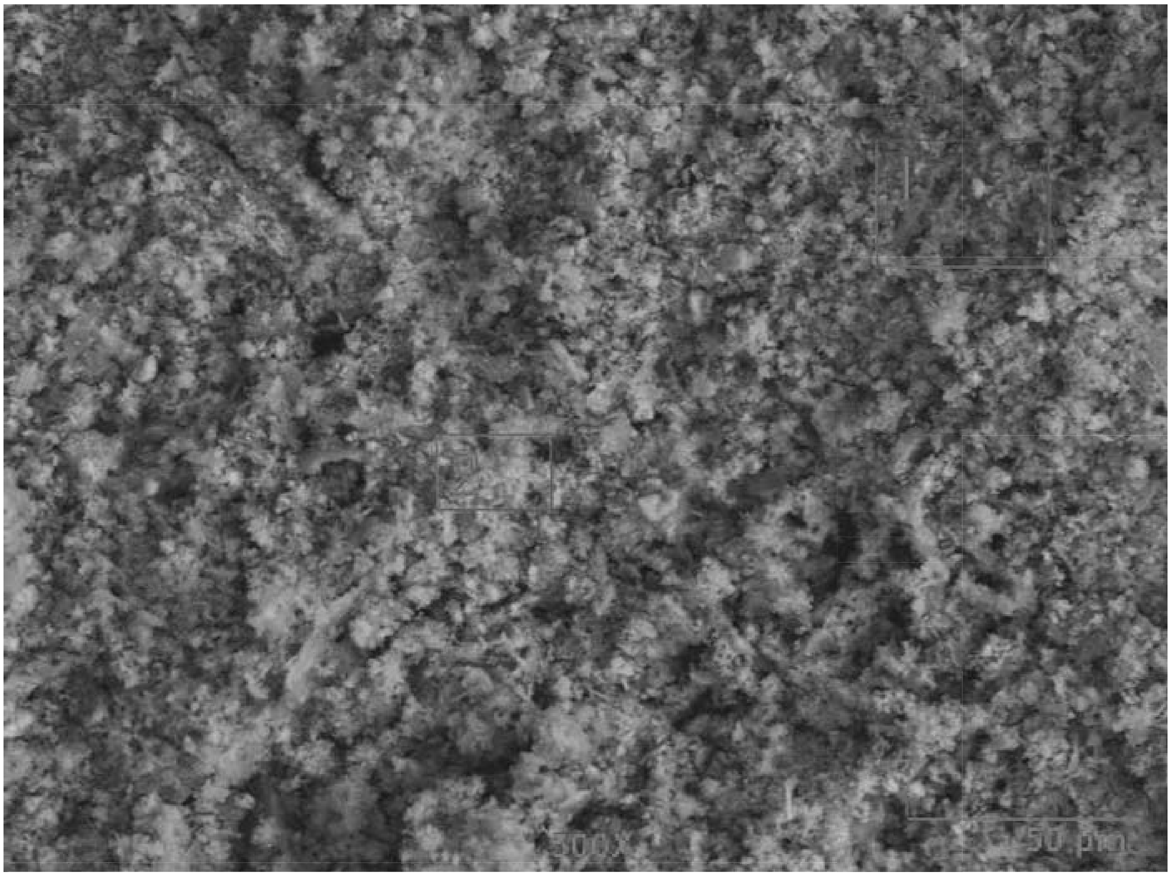


FIGURE 102
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 101

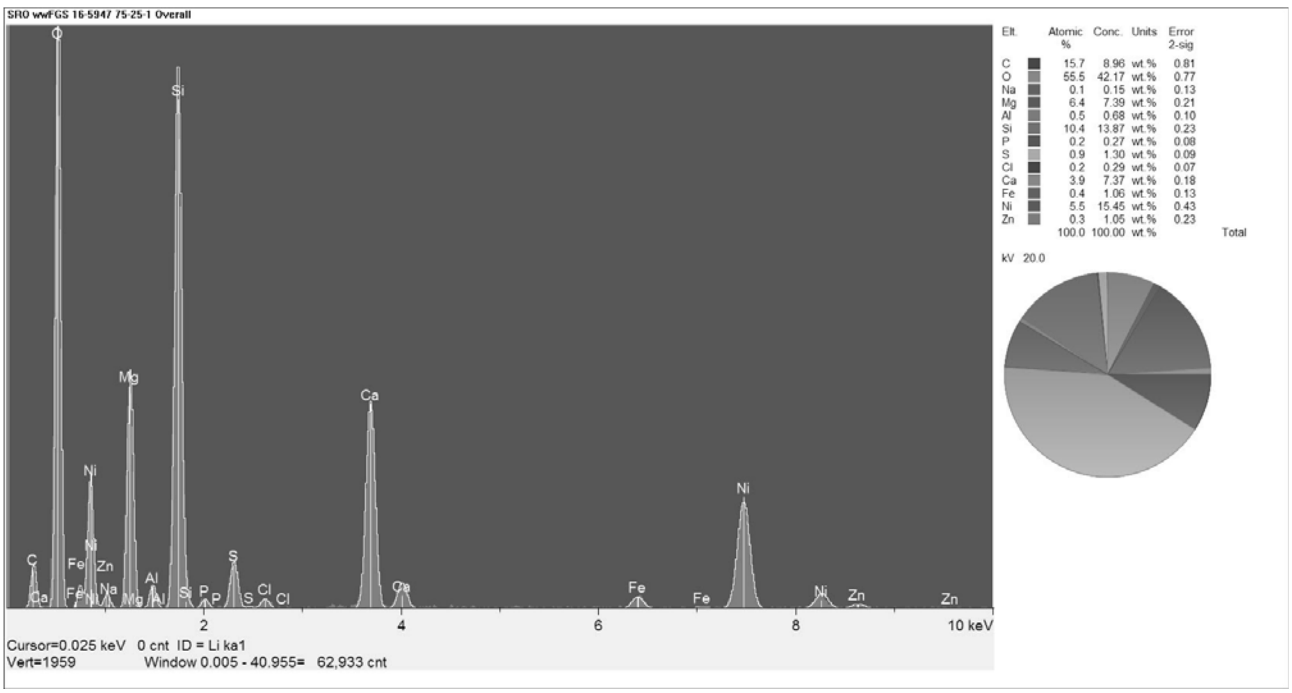


FIGURE 103
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 101

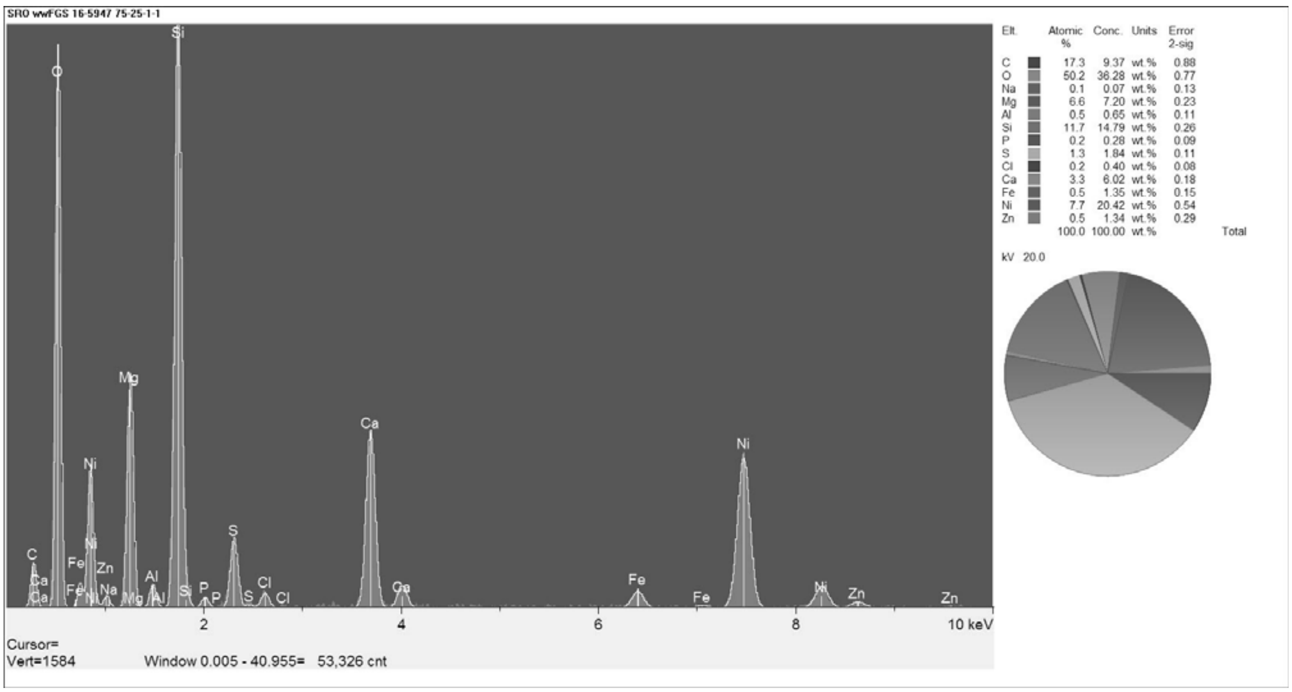


FIGURE 104
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 101

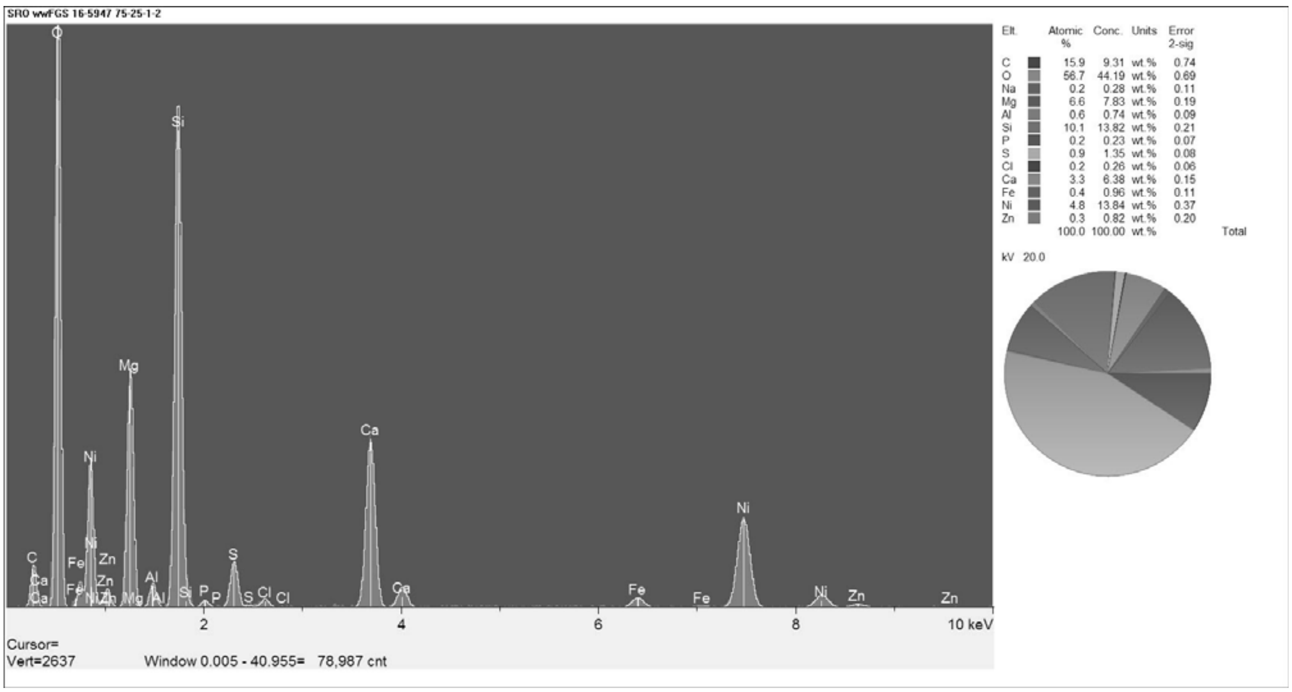


FIGURE 105
SCANNING ELECTRON MICROSCOPE PHOTOMICROGRAPH OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE

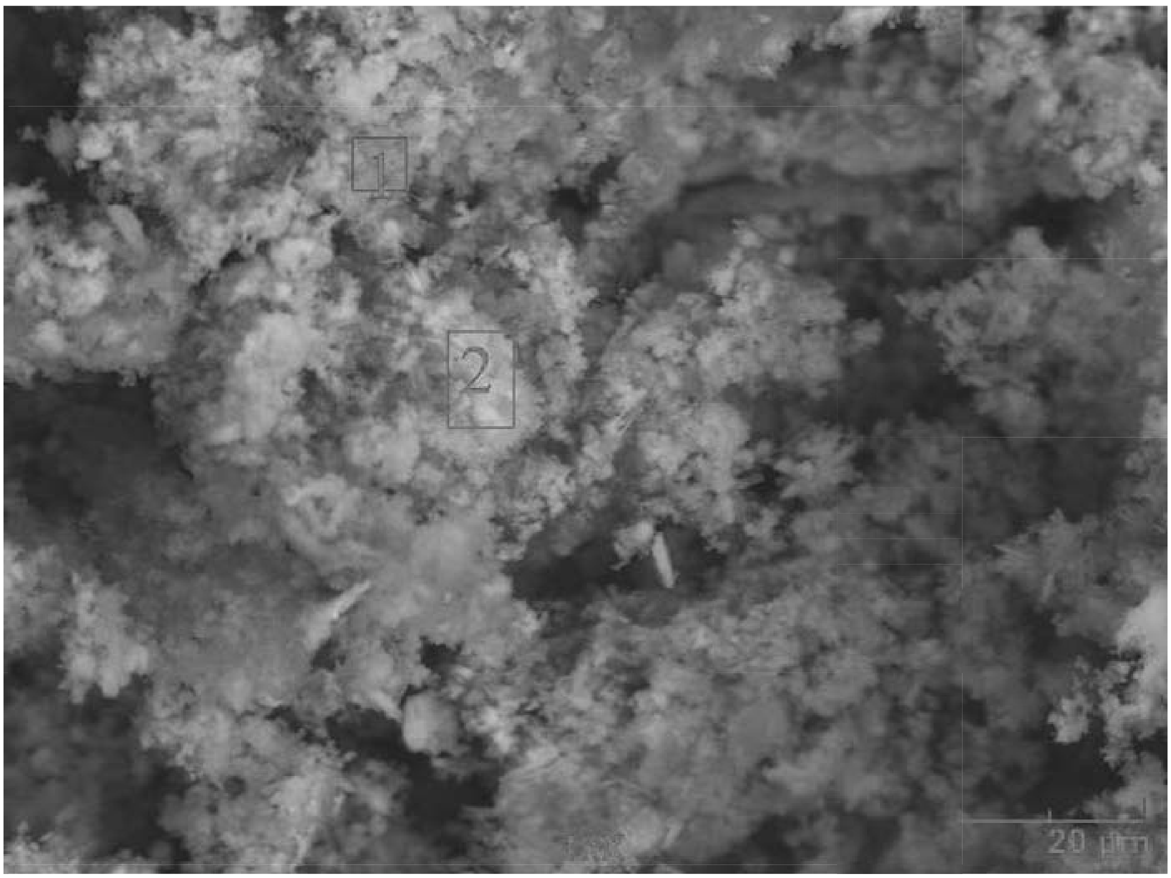


FIGURE 106
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES SHOWN IN FIGURE 105

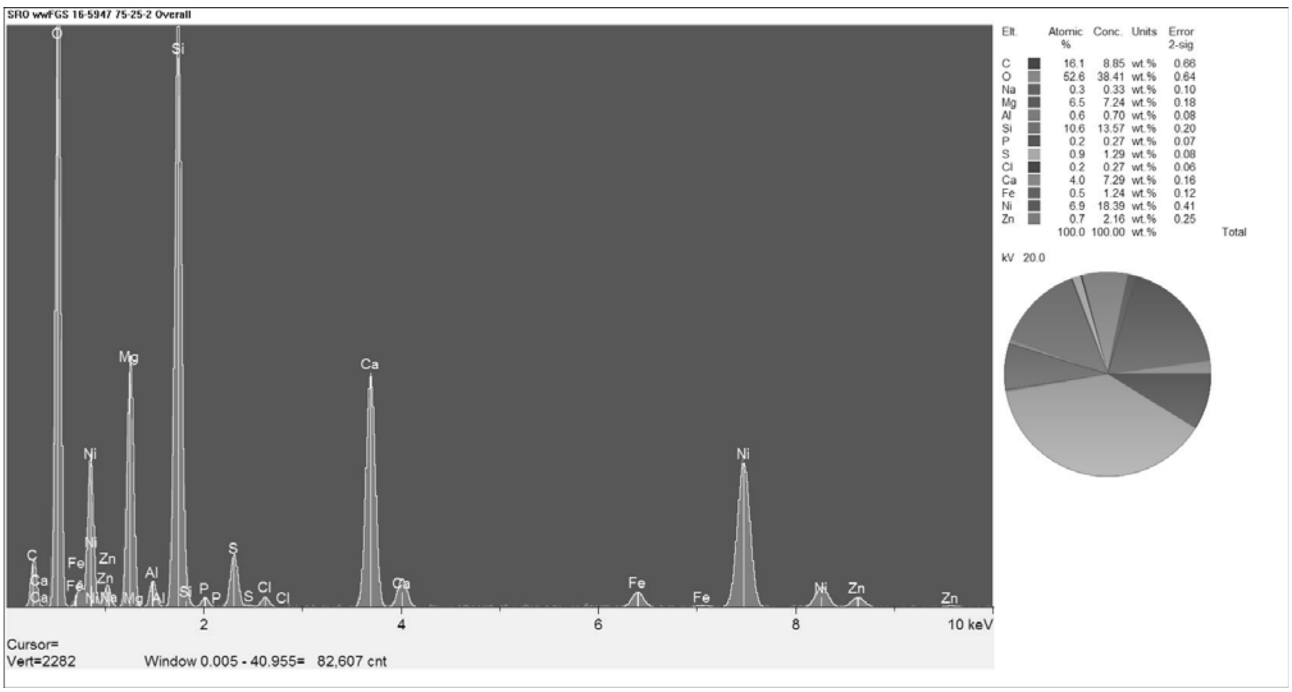


FIGURE 107
EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #1 IN FIGURE 105

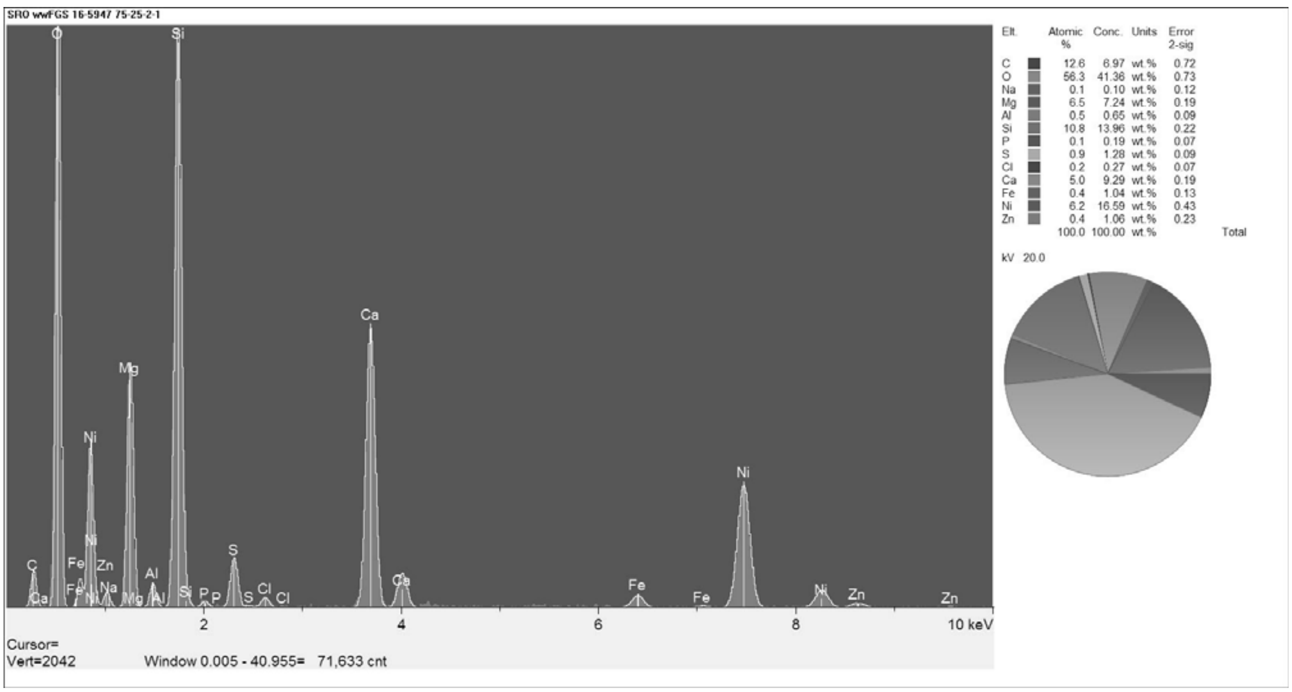


FIGURE 108

EDS MICROCHEMICAL ANALYSIS OF THE 75:25 SRO:WWFGS SAMPLE PRECIPITATE PARTICLES LABELED #2 IN FIGURE 105

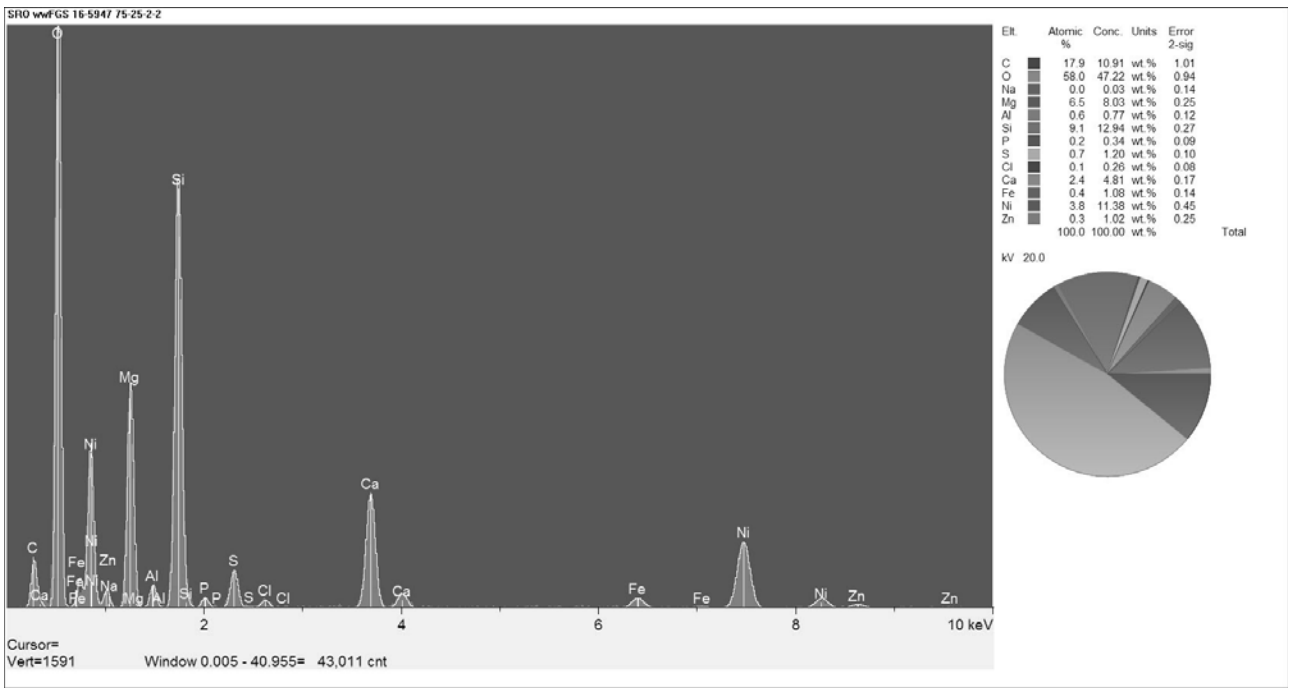


FIGURE 109

PHOTOGRAPH SHOWING THE SOLUBILITY OF THE SRO PRETEST PRECIPITATE, THE FGS PRETEST PRECIPITATE, AND THE 100% FGS POST TEST SAMPLE IN 12.1 M HYDROCHLORIC ACID

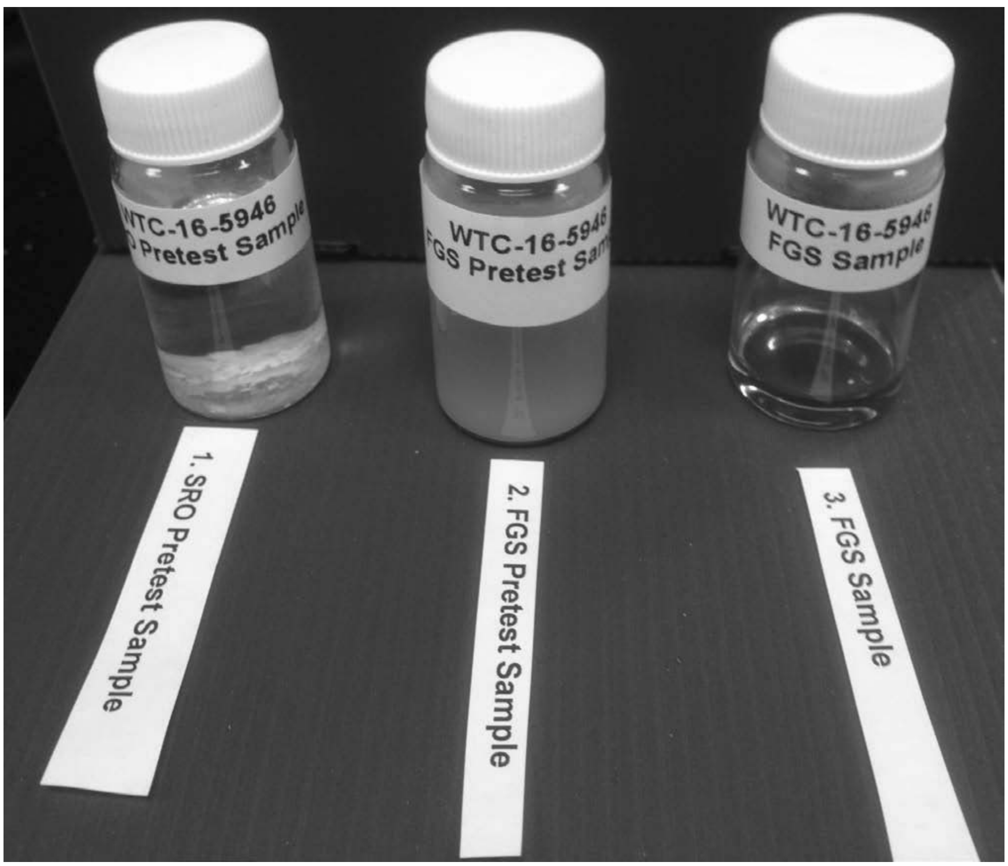


FIGURE 113

PHOTOGRAPH SHOWING THE SOLUBILITY OF THE 100% SRO POST TEST PRECIPITATE, THE 100% WWFGS POST TEST PRECIPITATE, AND THE 25%: 75% SRO:FGS POST TEST SAMPLE IN 12.1 M HYDROCHLORIC ACID

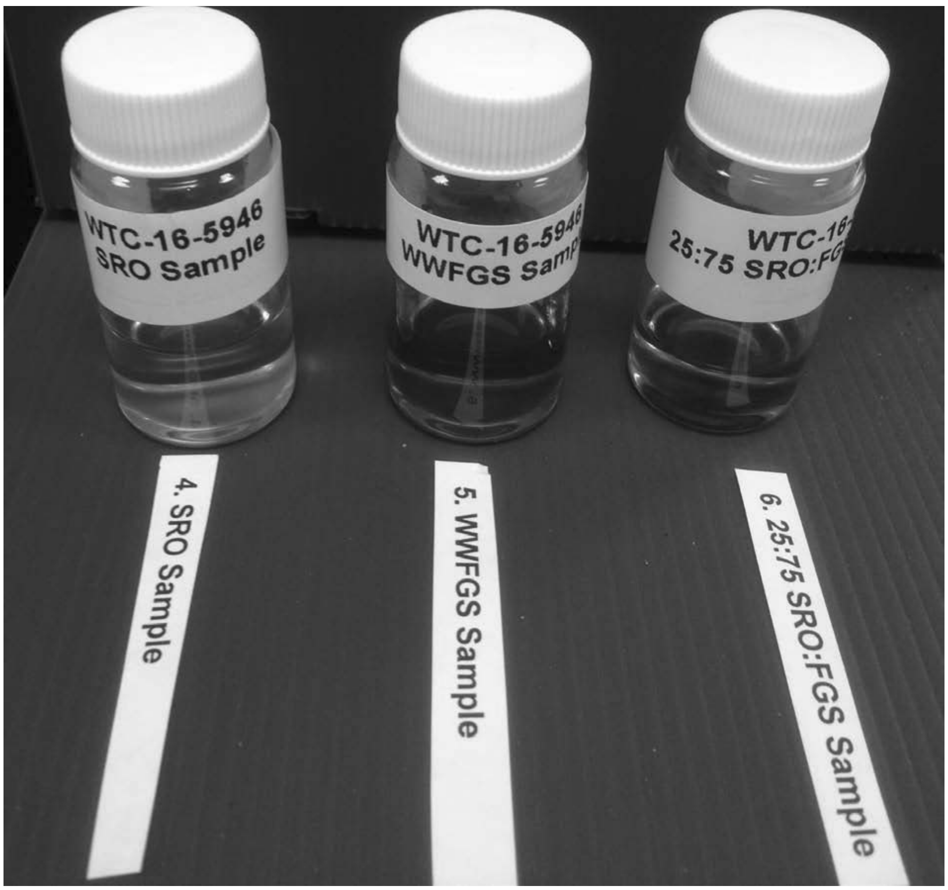


FIGURE 111

PHOTOGRAPH SHOWING THE SOLUBILITY OF THE 50%:50% SRO:FGS POST TEST PRECIPITATE, THE 75%:25% SRO:FGS POST TEST PRECIPITATE, AND THE 25%:75% SRO:WWFGS POST TEST PRECIPITATE IN 12.1 M HYDROCHLORIC ACID

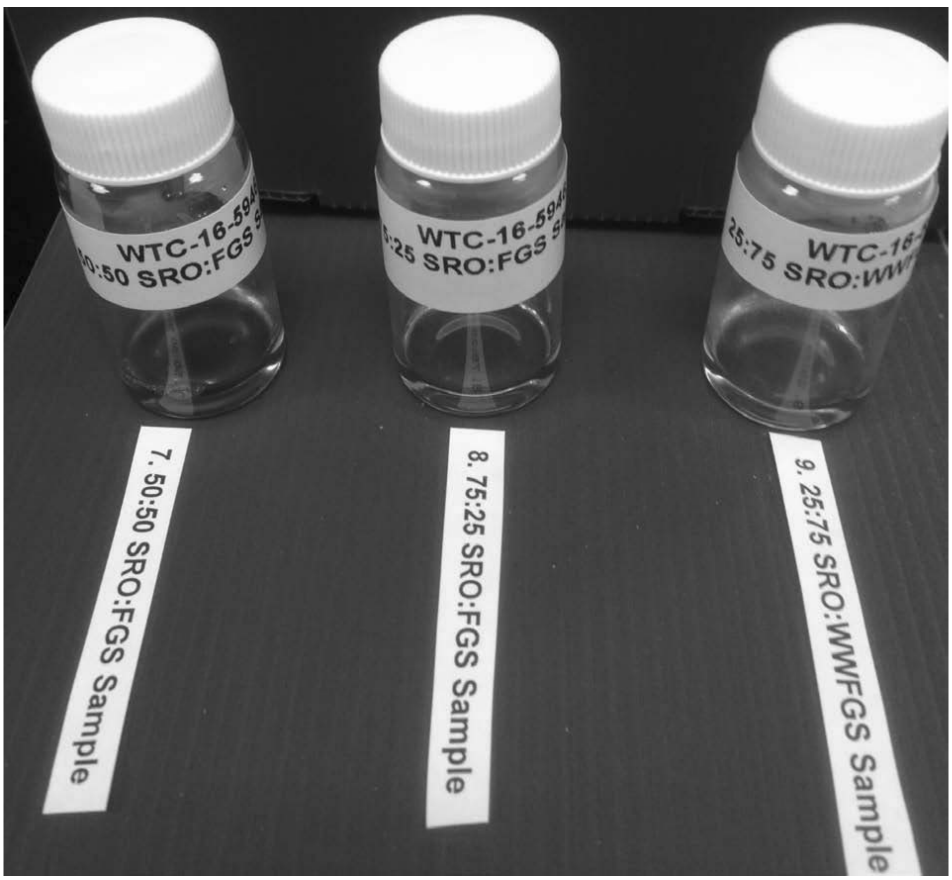
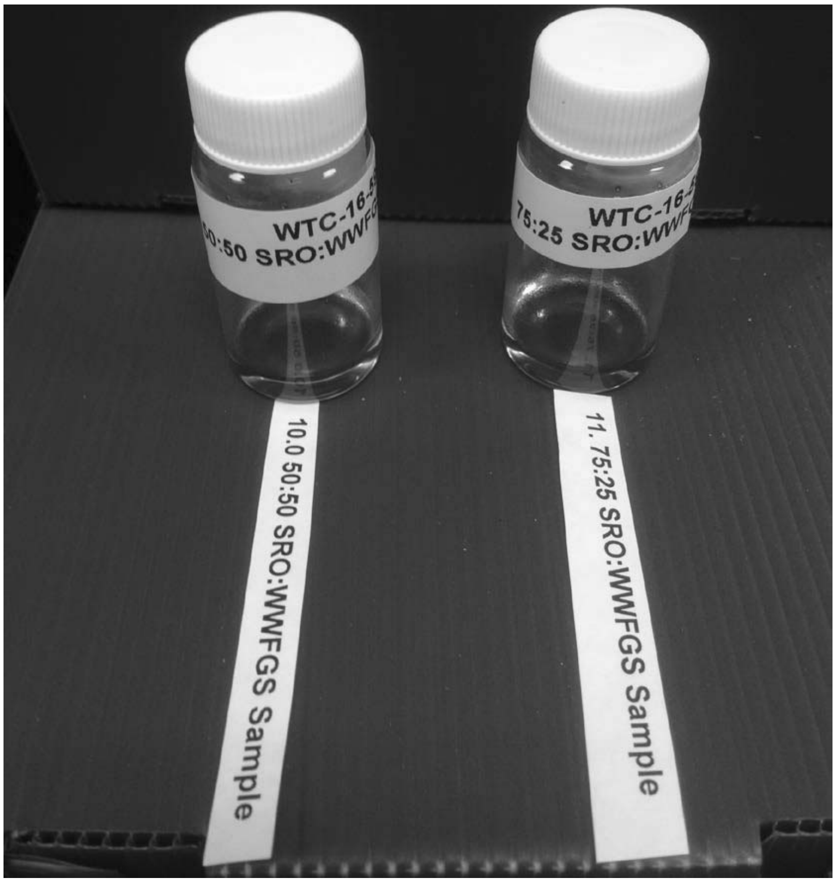


FIGURE 112

PHOTOGRAPH SHOWING THE SOLUBILITY OF THE 50%:50% SRO:WWFGS POST TEST PRECIPITATE AND THE 75%:25% SRO:WWFGS POST TEST PRECIPITATE IN 12.1 M HYDROCHLORIC ACID



2015 ANNULUS PRESSURE TEST (MIT)
NAVAJO REFINING

WDW NO. 1 MEWBOURNE (30-015-27592)
WDW NO. 2 CHUKKA (30-015-20894)
WDW NO. 3 GAINES (30-015-26575)

ARTESIA,NM

SEPTEMBER 21, 2015

SUBSURFACE TECHNOLOGY, INC.

Houston, TX

A Company of

WSP | PARSONS BRINCKERHOFF

Project No. 185818-7176

Prepared by Tim Jones

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APPENDICES

EXECUTIVE SUMMARY

Subsurface Construction Corp. (Subsurface) conducted annulus pressure tests (MITs) on WDW-1 Mewbourne, WDW-2 Chukka, and WDW-3 Gaines on Monday, September 21, 2015. The tests were not witnessed by a NM OCD representative. The tests were witnessed by Hank Lichtenwaldt for Subsurface. All annulus pressure tests were successful.

1.0 ANNULUS PRESSURE TEST FOR WDW-1

On September 21, a 1000 psig chart recorder, with spring weight 0-1000 psig, was rigged up to the casing-tubing annulus via a 2 inch bull plug with ½" NPT connection. The annulus line from the well annulus monitoring system (WAMS) to the wellhead was blocked in and the annulus pressure was recorded from 1352 hours to 1423 hours. During this 30-minute test, the annulus pressure increased from 645 psig to 655 psig. The 10 psig change in annulus pressure is within the NM OCD maximum allowable ± 10% annulus pressure change. The change in annulus pressure was 1.55%. This successful annulus pressure chart can be found in Appendix A. The chart calibration sheet can be found in Appendix D.

2.0 ANNULUS PRESSURE TEST FOR WDW-2

On September 21, a 1000 psig chart recorder, with spring weight 0 - 1000 psig, was rigged up to the casing-tubing annulus via a 2 inch bull plug with ½" NPT connection. The annulus line from the well annulus monitoring system (WAMS) to the wellhead was blocked in and the annulus pressure was recorded from 1502 hours to 1534 hours. During this 30 minute test, the annulus pressure decreased from 315 psig to 305 psig. The 10 psig change in annulus pressure is within the NM OCD maximum allowable ± 10% annulus pressure change. The change in annulus pressure was 3.17%. This successful annulus pressure chart can be found in Appendix B. The chart calibration sheet can be found in Appendix D.

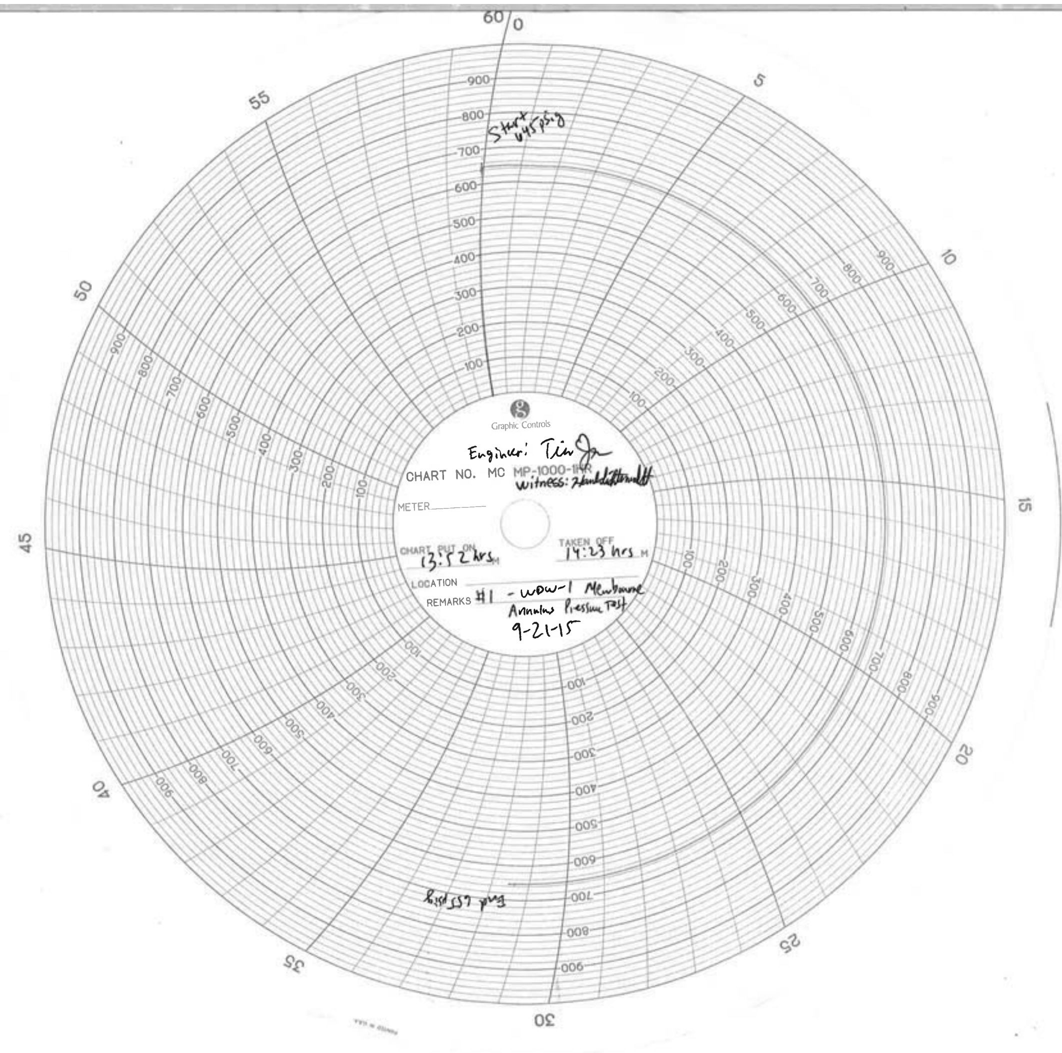
3.0 ANNULUS PRESSURE TEST FOR WDW-3

On September 21, a 1000 psig chart recorder, with spring weight 0 - 1000 psig, was rigged up to the casing-tubing annulus via a 2 inch bull plug with ½" NPT connection. The annulus line from the well annulus monitoring system (WAMS) to the wellhead was blocked in and the annulus pressure was recorded from 1632 hours to 1703 hours. During this 30 minute test, the annulus pressure increased from 705 psig to 710 psig. The 5 psig change in annulus pressure is within the NM OCD maximum allowable ± 10% annulus pressure change. The change in annulus pressure was 0.71%. This successful annulus pressure chart can be found in Appendix C. The chart calibration sheet can be found in Appendix D.

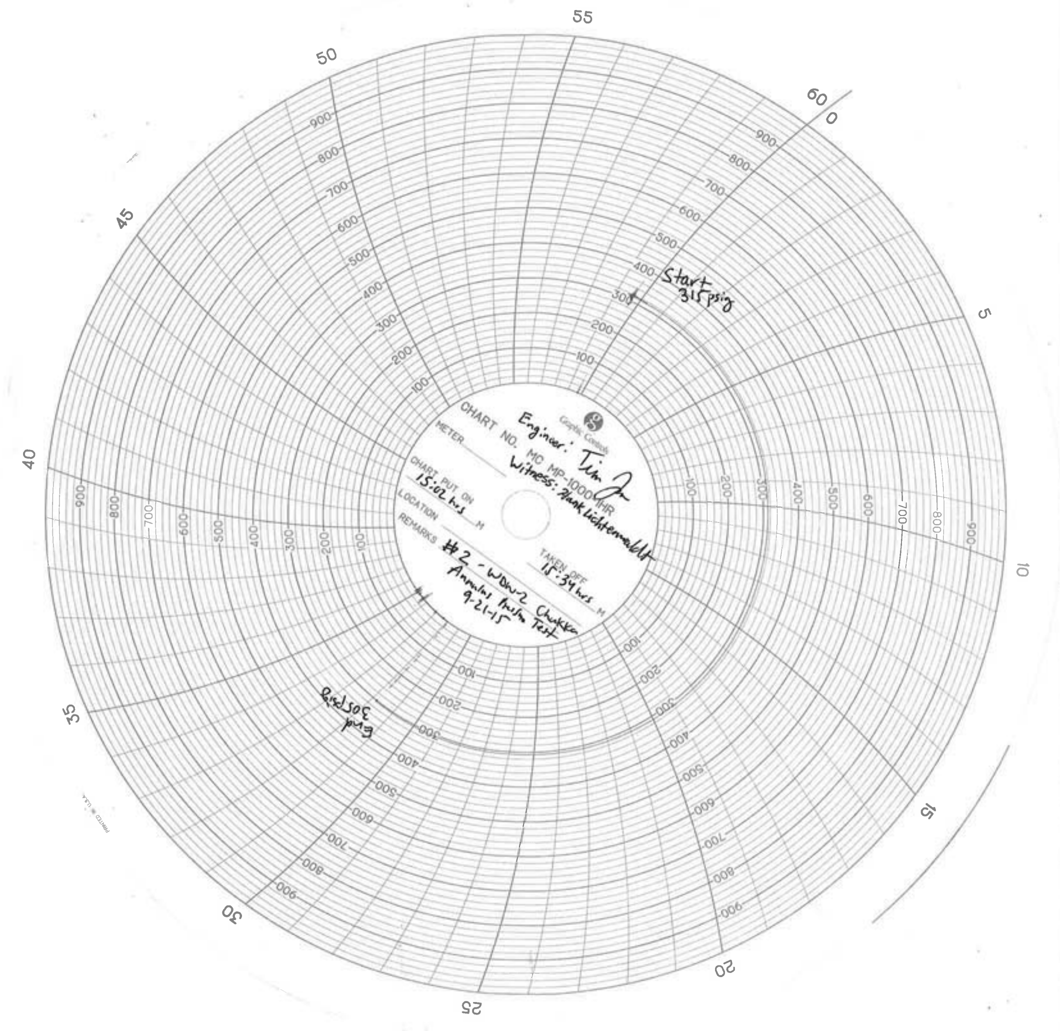
4.0 CONCLUSIONS

The annulus pressure tests (MITs) were successful for all three disposal wells. Please refer to Appendix A-C for the pressure charts and Appendix D for the chart calibration sheet.

APPENDIX A

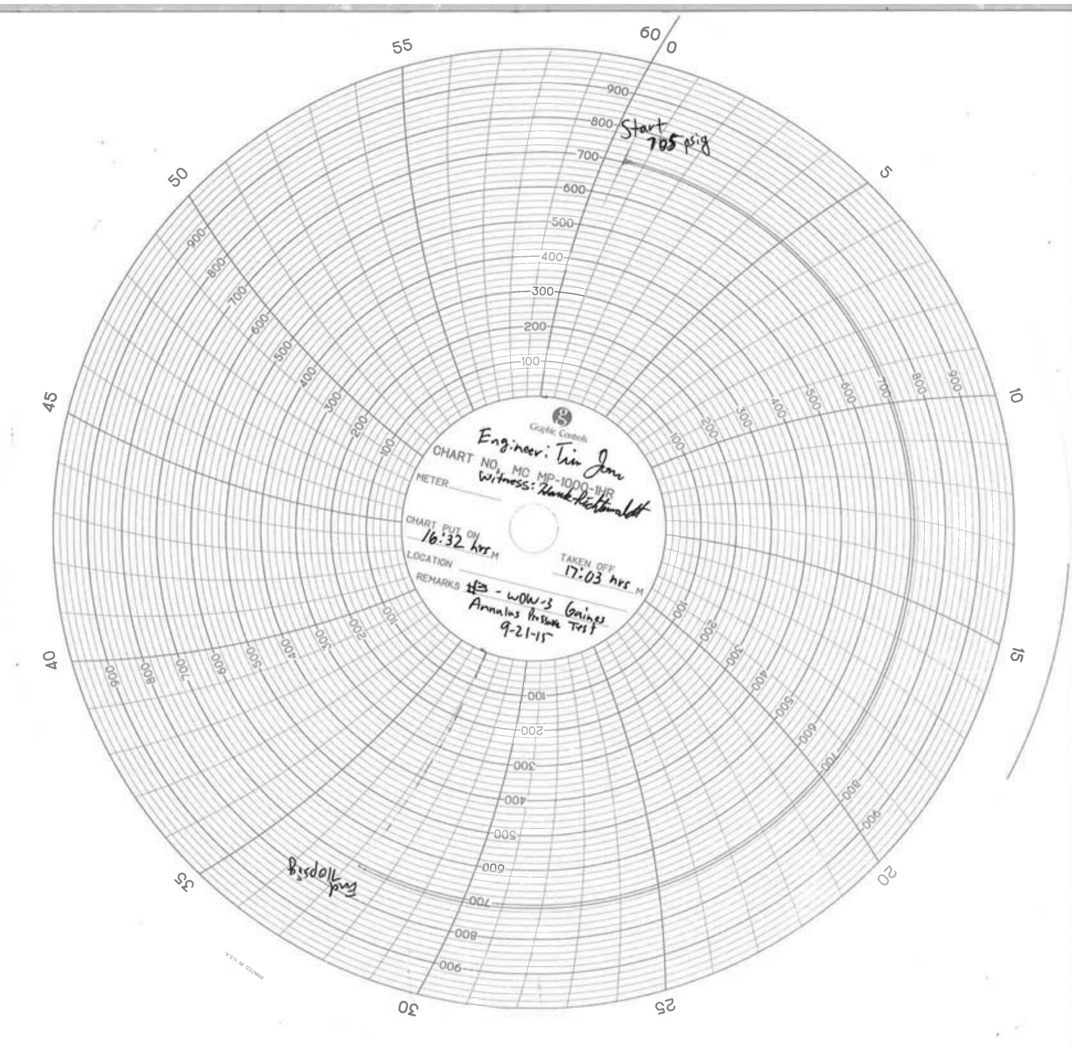

Graphic Controls
CHART NO. MC MP-1000-1H
METER
CHART PUT ON 13:52 hrs M
TAKEN OFF 14:23 hrs M
LOCATION
REMARKS #1 - WDW-1 Membrane Annulus Pressure Test
9-21-15

APPENDIX B



Graphic Controls
CHART NO. MC MP-1000 1HR
METER
CHART PUT ON 15:02 hrs
LOCATION
REMARKS #2 - WDW-2 Chukka Annulus Test 9-21-15
TAKEN OFF 15:34 hrs
Engineer: Tim
Witness:
Start 315 psig
End 305 psig
55
60 0
5
10
15
20
25
30
35
40
45
50

APPENDIX C


Start 705 psig
Graphic Controls
Engineer: Tim Jem
CHART NO. MC MP-1000-1HR
Witness: Hank Rechtenwaldt
METER
CHART PUT ON 16:32 hrs M
LOCATION
TAKEN OFF 17:03 hrs M
REMARKS #3 - WOW-3 Gaines Annulus Pressure Test 9-21-15
End 695 psig

APPENDIX D

Wildcat Measurement Service, Inc.

416 East Main Street
P.O. Box 1836
Artesia, New Mexico 88211
Office: (575)746-3481
Toll Free: 1-888-421-9453

Calibration Certificate

Company Name: Globe Energy.
Recorder Type: Barton.
Recorder Serial:# 242A-8717.

Recorder Pressure Range: 0-1000# Accuracy +/-: 0.2% PSIG
Temperature Range:__________ Deg F.

Increasing Pressure			Decreasing Pressure		
Applied Pressure	Indicated Pressure	Error%	Applied Pressure	Indicated Pressure	Error%
0.0#	0.0#	0	800#	800#	0
100#	100#	0	600#	600#	0
300#	300#	0	400#	400#	0
500#	500#	0	200#	200#	0
700#	700#	0	0.0#	0.0#	0
1000#	1000#	0			

Temperature Test		
Applied Temperature	Indicated Temperature	Error%

Certified Calibration Instrument Used
Gauge: Crystal.
Deadweight:__________.

Remarks:__________

Calibration Date: 08/11/2015.
Technician: [signature] .Jonnie Aldrich

2016 ANNUAL BOTTOM-HOLE PRESSURE SURVEY AND PRESSURE FALLOFF TEST REPORT

NAVAJO REFINING

MEWBOURNE WELL NO. 1

Artesia, New Mexico

August 2016

Parsons Brinckerhoff

Houston, TX

A Company of

WSP | PARSONS BRINCKERHOFF

Project No. 50904A

Prepared by Brenda Love

Brenda Love

Reviewed by Tim Jones

Tim Jones

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CERTIFICATION STATEMENT

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete.

I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Client: Navajo Refining
Well Name: WDW-1
Test Date(s): June 10 – 15, 2016

Name: Scott Shifflett
Title: Drilling and Completion Manager

Phone Number: 281-589-5900

Signature ______________________, P.E. Date Signed 8/30/2016
New Mexico Registration No. 19678

SCOTT C. SHIFFLETT
NEW MEXICO
19678
PROFESSIONAL ENGINEER

EXECUTIVE SUMMARY

WSP | Parsons Brinckerhoff was contracted by Navajo Refining Company (Navajo) to perform a pressure falloff test and bottom-hole pressure survey on Navajo's Mewbourne Well No. 1. The test was performed according to New Mexico Oil Conservation Division (OCD) falloff test guidelines (*New Mexico Oil Conservation Division UIC Class I Well Fall-Off Test Guidance, December 3, 2007*).

The test provides the state regulatory agency with the necessary information to access the validity of requested or existing injection well permit conditions and satisfy the permitting objective of protecting the underground sources of drinking water (USDW). Specifically, 40 CFR Part 146 states "the Director shall require monitoring of the pressure buildup in the injection zone annually, including at a minimum, a shutdown of the well for a time sufficient to conduct a valid observation of the pressure fall-off curve" (40 CFR§146.13 for Non-hazardous Class I Wells).

The falloff testing was conducted according to the testing plan submitted to and approved by the NM OCD. The testing plan stated that, all offset wells that inject into the injection interval would be shut-in for the duration of the test period. The testing consisted of a 111-hour injection period and a 32-hour falloff period. Bottom-hole pressure gauges were also placed in the offset wells Gaines Well No. 3 and Chukka Federal Well No. 2. These wells are owned by Navajo and are used to inject plant waste into the same intervals as the Mewbourne Well No. 1.

As prescribed by the guidelines, the report discusses supporting and background information in Sections 1 through 9. The one mile area of review (updated since the 2015 falloff testing) is discussed in Section 10 and geology in Section 11. Information on the offset wells is discussed in Section 12, daily testing activities in Section 13, and point of shut-in, in Section 14. The pressure falloff testing and analysis results are discussed in Section 15. The OCD required record keeping statement is discussed in Section 16.

1. FACILITY INFORMATION

a. Name: Navajo Refining Company (subsidiary of the Holly Corporation)
b. Facility Location: Highway 82 East, Artesia, New Mexico 88211
c. Operator's Oil and Gas Remittance Identifier (OGRID) Number: 223518

2. WELL INFORMATION

a. OCD UIC Permit Number: UIC-CLI-008-1
b. Well Classification: Class I Non-hazardous
c. Well Name and Number: Mewbourne Well No. 1
d. API Number: 30-015-27592
e. Well Legal Location: 660 FSL, 2310 FEL

3. CURRENT WELLBORE SCHEMATIC

The Mewbourne Well No. 1 wellbore schematic is presented in Figure 1. The schematic has all data as requested by the guidelines and includes the following:

a. Tubing: 4 ½ inch, 11.6 pound per foot, steel construction, API grade N-80, with long thread connections (LT&C).

b. Packer: Arrow X-1, 7 inch by 3 ½ inch set in tension at 7879 feet.

c. Tubing Length: 7879 feet. There are no profile nipples in the tubing or the packer as this was not a requirement of the permit.

d. Size, Type, and Depth of Casing: There are three casing strings in the well. The information for these casing strings was obtained from OCD records on file with the state and geophysical logs. The casing strings are:

   i. 13 3/8 inch, 48 pound per foot (lb/ft), steel construction, API grade J-55, with short thread connections (ST&C), set at a depth of 390 feet. The casing was cemented to the surface with 525 sacks of cement. The casing was set in open hole with a diameter of 17.5 inches. This information was obtained from OCD records.

   ii. 9 5/8 inch, 36 lb/ft, steel construction, API grade J-55, ST&C, set at a depth of 2555 feet. The casing was cemented to the surface with 1000 sacks of cement. The casing was set in open hole with a diameter of 12.25 inches. This information was obtained from OCD records.

iii. 7-inch, 26 lb/ft and 29 lb/ft, steel construction, API grade N-80 and P-110, LT&C, set at a depth of 9094 feet. The casing was cemented to surface in two stages with 1390 sacks of cement. The casing was set in open hole with a diameter of 8.75 inches. The top cement was verified with a CBL run on July 23, 1998. The remainder of the information was obtained from OCD records.

iv. A cement plug at 9004 feet isolates the lower section of the original borehole. This information was obtained from OCD records.

e. The top of cement was determined from a CBL run in the 7-inch casing string on July 23, 1998. The top of cement in the 7 inch casing was found at the surface. The top of cement in the 9 5/8 inch and 13 3/8 inch casing strings was verified through OCD records and volume calculations.

f. The 7 inch casing was perforated on July 24 and July 27, 1998. The casing was perforated with a 0.5 inch diameter hole at 2 shots per foot on a 60° phasing. The perforations are located between 7924 feet and 8188 feet and from 8220 feet to 8476 feet.

g. The total depth of the well is 10,200 feet with the plug back depth at 9004 feet. On September 22, 2015, fill was tagged at 8995 feet.

The bottom-hole pressure gauge run in the Mewbourne Well No. 1 for the pressure falloff testing consisted of one memory (top of the perforations) (MRO) pressure gauge that was placed at 7924 feet.

4. ELECTRIC LOG ENCOMPASSING THE COMPLETED INTERVAL

The dual induction log is presented in Appendix A and encompasses the completed interval between 7924 feet and 8476 feet. The dual induction log was submitted to the OCD with the original permit after the well was drilled by the Mewbourne Oil Company. The log was resubmitted to the OCD when the well was re-permitted as a Class I injection well.

5. RELEVANT PORTIONS OF THE POROSITY LOG USED TO ESTIMATE FORMATION POROSITY

The neutron density log is presented in Appendix B and encompasses the completed interval between 7924 feet and 8476 feet. The neutron density log was submitted to the OCD with the original permit after the well was drilled by Mewbourne Oil Company. The log was resubmitted to the OCD when the well was re-permitted as a Class I injection well. The porosity of the formation, 10%, and the reservoir thickness, 175 feet, were determined from this log. These values were used in the analysis of the pressure falloff data (Section 15). Additional information concerning the geology of the injection reservoir is discussed in Section 11.

6. PVT DATA OF THE FORMATION AND INJECTION FLUID

The Mewbourne Well No. 1 was recompleted in July 1998, prior to the issuance of the current well testing guidelines (December 3, 2007). At the time, no directives were in place to test formation fluids or derive formation characteristics from cores. However, reservoir fluid samples were obtained during the recompletion and the average density and average total dissolved solids (TDS) were measured at 1.03 g/l and 26,500 mg/l, respectively. The analytical results of the analysis of the formation fluid are summarized in Table I.

The viscosity of the formation fluid, formation water compressibility, and total system compressibility were estimated in reference to bottom-hole temperature using industry accepted correlations. These correlations are found in the Society of Petroleum Engineer's "Advances in Well Test Analysis, Monograph Volume 5" and "Pressure Buildup and Flow Tests in Wells, Monograph Volume 1".

a. Estimation of formation fluid and reservoir rock compressibility:

The fluid compressibility of the formation brine was estimated for a sodium chloride solution (26,500 mg/l) at the bottom-hole temperature of 127°F using Appendix C (Figure D.16 SPE Monograph 5). This value was 2.9 x 10^{-6} psi^{-1}. The formation pore volume compressibility was estimated using Appendix D (Figure G.5 SPE Monograph 1). This value was 5.5 x 10^{-6} psi^{-1}. The total system compressibility is the sum of the fluid compressibility and the pore volume compressibility, 8.4 x 10^{-6} psi^{-1}. The temperature used with the correlations was recorded during the temperature survey conducted in the Mewbourne Well No. 1 on July 23, 1998, and included in this report as Appendix E.

b. Formation fluid viscosity with reference temperature:

The formation fluid had a TDS concentration of 26,500 mg/l. This equates to an approximate equivalent percentage of NaCl of 4.5%. The average viscosity of the formation fluid was estimated using Appendix F (Figure D.35 SPE Monograph 5). This value was 0.57 centipoise (cp) at 127°F.

c. Formation fluid specific gravity/density with reference temperature:

The average formation fluid density was measured at 1.03 g/l at 70°F (Table I).

d. Injection fluid specific gravity, viscosity and compressibility with reference temperature:

The specific gravity and pH of the refinery waste water were measured during the injection portion of the reservoir testing. The specific gravity was 1.01 (8.41 pounds per gallon). This equates to an approximate equivalent percentage of NaCl of 4%. Using the same methodology described above, the viscosity of the injected fluid was 0.54 cp at 127°F. The compressibility of the injected plant waste was 2.9 x 10^{-6} psi^{-1} at 127°F.

7. DAILY RATE HISTORY DATA (MINIMUM OF ONE MONTH PRECEDING THE FALLOFF TEST)

The rate history used in the analysis of the pressure falloff data began on March 31, 2016 and ends on June 15, 2016. The daily rate history is summarized in Appendix G.

8. CUMULATIVE INJECTION INTO THE FORMATION FROM TEST WELL AND OFFSET WELLS

The total volume of fluid injected into all three wells as of June 15, 2016, was 3,352,496,910 gallons. The volume of fluid injected into the Mewbourne Well No. 1 was 1,671,316,978 gallons. The volume of fluid injected into the Chukka Well No. 2 was 1,097,019,675 gallons. The volume of fluid injected into the Gaines Well No. 3 was 584,160,257 gallons. The area of review (AOR) indicates that there are two wells injecting into the intervals in which the Navajo wells inject. The volumes injected were obtained from plant records.

9. PRESSURE GAUGES

One (1) downhole pressure gauge (with two readings) was used for the Mewbourne Well No. 1 buildup and falloff testing. The downhole pressure gauge was set at 7,924 feet. Bottom-hole pressure gauges were also placed in each of the offset wells: Gaines Well No. 3 and Chukka Well No. 2. The pressure gauges were set at 7660 feet in the Gaines Well No. 3 and at 7570 feet in the Chukka Well No. 2.

a. Describe the type of downhole surface pressure readout gauge used including manufacture and type:

   In the Mewbourne Well No. 1, an MRO pressure gauge was used to record the pressure and temperature data during the injection/falloff testing. The gauge was a sapphire crystal gauge. The manufacturer of the MRO pressure gauge (Serial No. SP-79240R) is Spartek Systems.

   In the Gaines Well No. 3, an MRO pressure gauge was used to monitor the bottom-hole pressure and temperature during the testing of the Mewbourne Well No. 1. The gauge was a sapphire crystal gauge with Serial No. SP-78527. The gauge is manufactured by Spartek Systems.

   In the Chukka Well No. 2, an MRO pressure gauge was used to monitor the bottom-hole pressure and temperature during the testing of the Mewbourne Well No. 1. The gauge was a sapphire crystal gauge with Serial No. SP-21726. The gauge is manufactured by Spartek Systems.

b. List the full range, accuracy and resolution of the gauge:

In Mewbourne Well No. 1, the MRO pressure gauge, Serial No. SP-79240R has a full range of 15 psi to 15,000 psi, an accuracy of 0.050% of full scale, and a resolution of 0.01% of full scale. A surface pressure gauge was not installed during testing.

In Gaines Well No. 3, the MRO pressure gauge, Serial No. SP-78527, has a full range of 50 psi to 14.996.63 psi, an accuracy of 0.022% of full scale, and a resolution of 0.01% of full scale.

In Chukka Well No. 2, the MRO pressure gauge, Serial No. SP-21726, has a full range of 13.14 psi to 16,001.81 psi, an accuracy of 0.020% of full scale, and a resolution of 0.01% of full scale.

c. Provide the manufacturer's recommended frequency of calibration and a calibration certificate showing date the gauge was last calibrated:

The certificate of calibration for each of the pressure gauges used during the testing are included as Appendix H. The manufacturer's recommended calibration frequency is one year.

10. ONE MILE AREA OF REVIEW (AOR)

Federal Abstract Company was contracted by WSP | Parsons Brinckerhoff and instructed to undertake a review of well changes made within a one-mile area of review (AOR) of the Mewbourne Well No. 1, Chukka Well No. 2, and Gaines Well No. 3. In 2009, an update of the original AOR, submitted with the Discharge Application Permit 2003, was completed within the one-mile AOR for all three wells. The current update includes all existing wells within the one-mile AOR and any changes that have occurred to these wells since the 2015 update.

No new fresh water wells were reported within the search area since the submittal of the 2015 report. The discharge application lists the water wells located in the Area of Review.

a. Identify wells located within the one mile AOR:

Table II also contains a listing of all wells within the one-mile AOR of Mewbourne Well No. 1, Chukka Well No. 2, and Gaines Well No. 3. Figure 6 is a Midland Map Company base map of the area containing the one mile AOR.

b. Ascertain the status of wells within the one mile AOR:

Table II contains a listing of all wells within the one-mile AOR, with their current status. Tables III through XII contain a list of all wells within the one-mile AOR that have had modifications to the current permit or have had new drilling and/or completion permits issued since the 2015 pressure falloff report.

Fifty-nine (59) wells were found in which the owner had changed. No new plugged and abandoned oil and gas well was found. One (1) well was placed in temporarily abandoned status. No wells were found that were returned to production status. One (1) well was found that had been recompleted.

There were sixty-six (66) new drills and permits to drill, of which none penetrated the Wolfcamp interval. All plugged and abandoned wells were successfully plugged and isolated from the Mewbourne Well No. 1, Chukka Well No. 2, and Gaines Well No. 3 injection intervals according to current OCD records.

c. Provide details on any offset producers and injectors completed in the same interval:

Navajo has two injection wells in the same interval. Mewbourne Well No. 1 is listed as ID No. 59 in Table II and no changes have occurred to this well. Chukka Well No. 2 is listed as ID No. 120 in Table II and no changes have occurred to this well. The Gaines Well No. 3 is listed as ID No. 861 in Table XI. The wellbore schematics for the Gaines Well No. 3 and Chukka Well No. 2 are presented as Figure 3 and Figure 4, respectively.

11. GEOLOGY

The injection zones are porous carbonates of the lower portion of the Wolfcamp Formation, the Cisco Formation, and the Canyon Formation. These formations occur in the Mewbourne Well No. 1, the Chukka Well No. 2, and the Gaines Well No. 3 at the depths shown in the table below.

Injection Zone Formation	Mewbourne Well No. 1 (KB = 3,693 ft)		Chukka Well No. 2 (KB = 3,623 ft)		Gaines Well No. 3 (KB = 3,625 ft)	
	MD below KB (ft)	SS Depth (ft)	MD below KB (ft)	SS Depth (ft)	MD below KB (ft)	SS Depth (ft)
Lower Wolfcamp	7450	-3757	7270	-3647	7303	-3678
Cisco	7816	-4123	7645	-4022	7650	-4025
Canyon	8,475	-4,782	8,390	-4767	8390	-4765
Base of Injection Zone (base of Canyon)	9016	-5323	8894	-5271	8894	-5269

d. Description of the geological environment of the injection interval:

The lower portion of the Wolfcamp Formation (Lower Wolfcamp) is the shallowest porous unit in the proposed injection interval. The Wolfcamp Formation (Permian-Wolf campaign age) consists of light brown to tan, fine to medium-grained, fossiliferous limestones with variegated shale interbeds (Meyer, 1966, page 69). The top of the Wolfcamp Formation was correlated for this study to be below the base of the massive, dense dolomites of the overlying Abo Formation. The base of the Wolfcamp coincides with the top of the Cisco Formation. The thickness of log porosity greater than 5% in the entire Wolfcamp Formation ranges from 0 feet to 295 feet in a band three miles wide that trends northeast-southwest across the study area.

The Cisco Formation (Pennsylvanian-Virgilian age) of the Northwest Shelf is described by Meyer (1966, page 59) as consisting of uniform, light colored, chalky, fossiliferous limestones interbedded with variegated shales. Meyer (1966, page 59) also describes the Cisco at the edge of the Permian basin as consisting of bio thermal (mound) reefs composed of thick, porous, coarse-grained dolomites. Locally, the Cisco consists of porous dolomite that is 745 feet thick in Chukka Well No. 2, 659 feet thick in Mewbourne Well No. 1, and 720 feet in Gaines Well No. 3. The total thickness of intervals with log porosity greater than 5% is approximately 310 feet in Mewbourne Well No. 1, 580 feet in Chukka Well No. 2, and 572 feet in Gaines Well No. 3. The total thickness with log porosity greater than 10% is approximately 100 feet in Mewbourne Well No. 1, 32 feet in Chukka Well No. 2, and 65 feet in Gaines Well No. 3. The thickness of the porous intervals in the Cisco ranges from 0 feet in the northwestern part of the study area to nearly 700 feet in a band three miles wide that trends northeast-southwest.

The Canyon Formation (Pennsylvanian-Missourian age) consists of white to tan to light brown fine grained, chalky, fossiliferous limestone with gray and red shale interbeds (Meyer, 1966, page 53). Locally, the Canyon occurs between the base of the Cisco dolomites and the top of the Strawn Formation (Pennsylvanian-Desmoinesian age). The total thickness of intervals with log porosity greater than 5% is 34 feet in Mewbourne Well No. 1, 30 feet in Chukka Well No. 2, and 10 feet in Gaines Well No. 3. No intervals appear to have log porosity greater than 10% in any of the three injection wells.

e. Discuss the presence of geological features, i.e., pinchouts, channels, and faults, if applicable:

From the geological study completed and submitted in the Discharge Plan Application and Application for Authorization to Inject, the reservoir appears to be continuous, with the possibility of anisotropic conditions extending to the west-southwest. The injection intervals that were studied are well confined by the Abo and Yeso low porosity carbonate beds, Tubbs shale, and Salado salt. The Cisco and Wolfcamp formations follow the Vacuum arch and have a southeasterly dip. No faults existed in the study area although, the study also shows that faulting occurs via the K-M fault located 6 miles northwest of Artesia and trends northeast-southwest. The distance to this fault line occurs no closer than 16 miles. No faults are known to exist in the confining zone within the AOR.

f. Provide a portion of relevant structure map, if necessary:

The structure map for Strawn is presented as Appendix I. The structure map for the Wolfcamp presented as Appendix J. The structure map for the Cisco is presented as Appendix K.

12. OFFSET WELLS

There are only four offset wells identified in the AOR that inject into the same interval: The Federal No. 1, the Chalk Bluff Federal Com No. 3, the Gaines Well No. 3 and the Chukka Well No. 2. The Gaines and Chukka were shut-in during the buildup and falloff portions of the testing.

a. Identify the distance between the test well and any offset well completed in the same injection interval:

The Mewbourne Well No. 1 is approximately 7900 feet from Gaines Well No. 3, the test well. The Chukka Well No. 2 is approximately 10,860 feet from the Mewbourne Well No. 1.

b. Report the status of the offset wells during both the injection and shut-in portions of the test:

Both the Gaines Well No. 3 and Chukka Well No. 2 were shut-in during the buildup and falloff portions of the testing. Bottom-hole pressure gauges were lowered into each well approximately 48 hours before shutting in the Mewbourne Well No. 1. The bottom-hole pressure and temperature data are graphically depicted in Figure 5 for the Gaines Well No. 3 and Figure 2 for the Chukka Well No. 2.

c. Describe the impact, if any, the offset wells had on the testing:

The offset wells were shut in prior to beginning the 30-hour injection period and remained shut-in during the falloff portion of the testing.

13. CHRONOLOGICAL LISTING OF THE DAILY TESTING ACTIVITIES (OPERATIONS LOG)

Appendix L contains the formal Chronology of Field Activities. This chronology was developed from the field activity reports.

a. Date of the testing:

The buildup portion of the testing started at 5:38 a.m. on June 9, 2016 at 9:31 a.m. and continued until June 14, 2016, at 5:38 a.m., when the Mewbourne Well No. 1 was shut-in. The falloff test ended on June 15, 2016 at 8:26 a.m. The total depth of the well was tagged at 8990 feet and five-minute gradient stops were made while pulling the pressure gauges out of the wellbore. After the pressure gauges were pulled out of the well on June 15, 2016, the well was turned over to Navajo plant operations personnel.

b. Time of the injection period:

The buildup portion of the testing began on June 9, 2016 when the injection rate was set at an average injection rate of 139 gallons per minute (gpm). The injection rate was held constant for 110.58 hours.

c. Type of injection fluid:

The injected fluid was non-hazardous waste water from the plant. The density of the injection fluid was periodically measured and averaged 8.34 pounds per gallon during the 110.58-hour injection period.

d. Final injection pressure and temperature prior to shutting in the well:

The final flowing pressure (P_{wf}) and temperature (T_{wf}) were 4,764.32 psia and 96.69°F, respectively.

e. Total shut-in time:

The Mewbourne Well No. 1 was shut-in, while offset wells shut-in, for 32.34 hours.

f. Final static pressure and temperature at the end of the fall-off portion of the test:

The final static pressure at 7924 feet was 4,440.62 psia. The final temperature was 100.44°F.

14. DESCRIBE THE LOCATION OF THE SHUT-IN VALVE USED TO CEASE FLOW TO THE WELL FOR THE SHUT-IN PORTION OF THE TEST

On the pipeline to the Mewbourne Well No. 1, there are two, 4 inch motor controlled valves installed on the incoming pipeline before the pod filters. Two 4 inch valves are installed between the pod filters and the wellhead. There is one 6 inch valve installed in the main line between the pod filters and the booster pump. A 4 1/16 inch wing valve is installed on the wellhead. All valves were closed during the falloff portion of the testing. A diagram of the wellhead is shown in Figure 7 and a diagram of the valve locations are shown in Figure 8.

15. PRESSURE FALLOFF ANALYSIS

The following discussion of the analysis of the pressure data recorded during the falloff testing of the Mewbourne Well No. 1 satisfies Sections 15 through 19 of Section IX, Report Components, of the OCD's falloff test guidelines. Where appropriate, the specific guideline addressed is annotated. Specific parameters used in the equations and discussed previously in this report are also annotated. The plots included with this report are summarized in Table VIII. The inclusion of these plots in this report satisfies OCD Guideline Section IX.18.

The pressure data obtained during the falloff test were analyzed using the commercially available pressure transient analysis software program PanSystem©. Appendix M contains the output from this software program. Figure 9 shows the pressure data recorded by the bottom-hole pressure gauge from the time the tool was in place through the 32.34 hour total shut-in period. Figure 10 shows the pressure and temperature data recorded by the bottom-hole pressure gauge from the time the tool was in place through the 32.34 hour falloff shut-in period. Figure 11 is a Cartesian plot of the injection rates versus time for the injection period used in the pressure falloff analysis. The superposition time function was used to account for all rate changes during the injection period. Figure 12 is a plot of the historical injection rates and surface pressures versus calendar time.

Figure 13 is a log-log diagnostic plot of the falloff data, showing change in pressure and pressure derivative versus equivalent shut-in time. The different flow regimes, wellbore storage, radial flow and change in reservoir characteristics, are indicated on the log-log plot and the superposition Horner plot (OCD Guideline Section IX.18.c and IX.18.d)

Wellbore storage begins at 0.017 hours and continues to an elapsed shut in time of 0.076 hours. Radial flow begins at an elapsed shut in time of 9.96 hours and continues until 19.40 hours (OCD Guideline Section IX.15.b).

The reservoir permeability was determined from the radial flow region of the superposition semi-log plot, Figure 14. The radial flow regime begins at a Superposition time of 2.198 and continues until a Superposition time of 1.908 at which time the pressure data departs the semi-log straight-line. Figure 15 shows an expanded view of the radial flow regime. The slope of the radial flow period, as calculated by the analysis software, 4.85777 psi/cycle (OCD Guideline Section IX.15.c). The injection rate just prior to shut in was 139.13 gpm which is equivalent to 4770 barrels per day (bbl/day).

An estimate of mobility-thickness (transmissibility, OCD Guideline Section IX.15.d), kh/μ, for the reservoir was determined to be 159,662 md-ft/cp using the following equation:

$$\frac{k\,h}{\mu} = 162.6\,\frac{q\,B}{m}$$

where,

kh/μ	=	formation mobility-thickness, millidarcy-feet/centipoise
q	=	rate prior to shut in, bpd
B	=	formation volume factor, reservoir volume/surface volume
m	=	slope of radial flow period, psi/cycle

$$\frac{k\ h}{\mu} = 162.6\,\frac{(4,770)(1.0)}{4.85777}$$

$$= 159,662\ \text{md} - \text{ft} / \text{cp}$$

The permeability-thickness (flow capacity, OCD Guideline Section IX.15.i), kh, was determined to be 91,007 md-ft by multiplying the mobility-thickness, kh/μ, by the viscosity of the reservoir fluid (see Section 6), $\mu_{reservoir}$, of 0.57 centipoises:

$$kh = \left(\frac{kh}{\mu}\right)\mu_{reservoir}$$

$$= (159,662) * (0.57)$$

$$= 91,007\ \text{md} - \text{ft}$$

The reservoir permeability (OCD Guideline Section IX.15.e) using the total thickness (see Section 5 and Section 11) of 175 feet was 520 md:

$$k = \frac{kh}{h}$$

$$= \frac{91,007}{175}$$

$$= 520\ \text{md}$$

To determine whether the proper viscosity was used in arriving at this permeability, the travel time for a pressure transient to pass beyond the waste front needs to be calculated (OCD Guideline Section VIII.5). The distance to the waste front is determined from the following equation:

$$r_{waste} = \left(\frac{0.13368\ V}{\pi\, h\ \phi}\right)^{1/2}$$

where,

r_{waste}	=	radius to waste front, feet
V	=	total volume injected into the injection interval, gallons
h	=	formation thickness, feet
ϕ	=	formation porosity, fraction
0.13368	=	constant

A cumulative volume of approximately 1,671,316,978 gallons of waste has been injected into Mewbourne Well No. 1 (see Section 8). The formation has a porosity of 0.10 (see Section 5 and Section 11).

The distance to the waste front was determined to be 2016 feet:

$$r_{waste} = \left(\frac{(0.13368)(1{,}671{,}316{,}978)}{(\pi)(175)(0.10)} \right)$$

$$= 2016 \text{ feet}$$

The time necessary for a pressure transient to traverse this distance is calculated from the following equation:

$$t_{waste} = 948 \frac{\phi \, \mu_{waste} \, c_t \, r^2_{waste}}{k}$$

where,

t_{waste}	=	time for pressure transient to reach waste front, hours
ϕ	=	formation porosity, fraction
μ_{waste}	=	viscosity of the waste at reservoir conditions, centipoise
r_{waste}	=	radius to waste front, feet
c_t	=	total compressibility of the formation and fluid, psi
k	=	formation permeability, millidarcies
948	=	constant

The pore volume compressibility is 8.4 x 10^{-6} psi^{-1} (see Section 6). The time necessary for a pressure transient to traverse the distance from the wellbore to the leading edge of the waste front would be 3.55 hours:

$$t_{waste} = 948 \frac{(0.10)(0.57)(8.4x10^{-6})(2016)^2}{520}$$

$$= 3.55 \text{ hours}$$

Since the time required to pass through the waste is less than the 9.96 hours required to reach the beginning of the radial flow period, the assumption that the pressure transient was traveling through reservoir fluid during the period of the semi-log straight line was correct.

The near wellbore skin damage (OCD Guideline Section IX.15.f) was determined from the following equation:

$$s = 1.151\left[\frac{p_{wf} - p_{1hr}}{m_1} - \log\left(\frac{k}{\phi\,\mu\,c_t\,r_w^2}\right) + 3.23\right]$$

where,

s	=	formation skin damage, dimensionless
1.151	=	constant
p_{wf}	=	flowing pressure immediately prior to shut in, psi
p_{1hr}	=	pressure determined from extrapolating the first radial flow semi-log line to a Δt of one hour, psi
m_1	=	slope of the first radial flow semi-log line, psi/cycle
k	=	permeability of the formation, md
ϕ	=	porosity of the injection interval, fraction
μ	=	viscosity of the fluid the pressure transient is traveling through, cp
c_t	=	total compressibility of the formation plus fluid, psi^{-1}
r_w	=	radius of the wellbore, feet
3.23	=	constant

The final measured flowing pressure was 4,764.32 psia. The pressure determined by extrapolating the radial flow semi-log line to a Δt of one hour, p_{1hr}, was 4,448.09 psia (calculated from the analysis software). The wellbore radius, r_w, is 0.3646 feet (completion records). Using these values in addition to the previously discussed parameters results in a skin of 67.09:

$$s = 1.151\left[\frac{4{,}764.32 - 4{,}448.09}{4.85777} - \log\left(\frac{520}{(0.10)(0.57)(8.4\text{x}10^{-6})(0.3646)^2}\right) + 3.23\right]$$

$$= 67.09$$

The change in pressure, Δp_{skin}, in the wellbore associated with the skin factor (OCD Guideline Section IX.15.g) was calculated using the following equation:

$$\Delta p_{skin} = 0.869(m)(s)$$

where,

0.869	=	constant
m	=	slope from superposition plot of the well test, psi/cycle
s	=	skin factor calculated from the well test

The change in pressure, Δp_{skin}, using the previously calculated and defined values was determined to be 283.21 psi:

$$\Delta p_{skin} = 0.869(m)(s)$$

$$= 0.869(4.85777)(67.09)$$

$$= 283.21\,\text{psi}$$

The flow efficiency (E, OCD Guideline Section IX.15.h) was determined from the following equation:

$$E = \frac{p_{wf} - \Delta p_{skin} - p_{static}}{p_{wf} - p_{static}}$$

where,

E	=	flow efficiency, fraction
p_{wf}	=	flowing pressure prior to shutting in the well for the fall-off test,
p_{static}	=	final pressure from the pressure falloff test
Δp_{skin}	=	pressure change due to skin damage

Using the previously determined parameters, the flow efficiency was calculated to be 0.13:

$$E = \frac{4{,}764.32 - 283.21 - 4{,}440.62}{4{,}764.32 - 4{,}440.62}$$

$$= 0.13$$

The radius of investigation (OCD Guideline Section IX.15.a) was calculated using the following equation:

$$R_{inv} = 0.029\sqrt{\frac{k\ \Delta t_s}{\phi\ \mu\ C_t}}$$

where,

k	=	formation permeability, millidarcies
Δt_s	=	elapsed shut-in time, hours
ϕ	=	formation porosity, fraction
μ	=	viscosity of the fluid the pressure transient is traveling through, cp
c_t	=	total compressibility of the formation plus fluid, psi^{-1}
0.029	=	constant

The radius of investigation, r_{inv}, using the previously defined values was determined to be 5435 feet:

$$R_{inv} = 0.029\sqrt{\frac{(520)(32.34)}{(0.10)(0.57)(8.4 \times 10^{6})}}$$

$$R_{inv} = 5,435 \text{ feet}$$

As indicated on Figure 13, the pressure data departs the radial flow region at an elapsed time from shut in of 19.40 hours. No pressure or temperature anomalies were noted that would cause this type of pressure response observed on the derivative log-log plot (OCD Guideline Section VIII.9). A review of the geology of the injection zones (see Section 11) indicates that all three of the formations in which the Mewbourne Well No. 1 injects into have varying thicknesses and porosities within the mapped area. Changes in formation thickness, porosity, and fluid viscosity can cause the slope changes seen on the derivative log-log plot. Because these changes occurred during the duration of the pressure falloff test, the reservoir analysis results are considered heterogeneous as opposed to homogeneous (OCD Guideline Section IX.17.b).

The Hall plot (OCD Guideline Section IX.18.h) is presented as Figure 16. No slope changes are seen in the plotted data.

A comparison of the current analysis results with previous analysis results as well as with the reservoir parameters submitted with the permit application is presented in Table IX (OCD Guideline Section IX.19).

On June 15, 2016, a static pressure gradient survey was conducted while pulling the pressure gauges out of the well. Static gradient stops were conducted at 7924 feet, 7000 feet, 6000 feet, 5000 feet, 4000 feet, 3000 feet, 2000 feet, 1000 feet, and at the surface. The bottom-hole pressure and temperature, after 32.34 hours of shut-in at 7924 feet, were 4440.62 psia and 100.44°F, respectively. The gradient survey is summarized in Table X. The data are graphically depicted in Figure 17.

16. NEW MEXICO OIL CONSERVATION DIVISION THREE YEAR RECORDING KEEPING STATEMENT

Navajo will keep the raw test data, generated during the testing, on file for a minimum of three years. The raw test data will be made available to OCD upon request.

TABLES

FIGURES

APPENDICES

TABLE I

FORMATION WATER ANALYSIS SUMMARY

Chemical	Mewbourne Well No. 1	Chukka Well No. 2	Gaines Well No. 3	Average
Date	July 31, 1998	June 14, 1999	Nov 8, 2006	
Fluoride (mg/l)	2.6	9.7	Not Detected	6.15
Chloride (mg/L)	19,000	15,000	10,447	14,815.67
NO3-N (mg/L)	<10	<10	--	<10
SO4 (mg/L)	2,200	2000	1,908	2,036
CaCO3 (mg/L)	1000	1210	--	1105
Specific Gravity (g/L)	1.034	1.0249	--	1.0295
TDS (mg/L)	33,000	20,000	--	26,500
Specific Conductance (uMHOs/cm)	52,000	43,000	--	47,500
Potassium (mg/L)	213	235	85.5	177.83
Magnesium (mg/L)	143	128	155	142
Calcium (mg/L)	390	609	393	464
Sodium (mg/L)	12,770	8,074	6,080	8,974.67
pH (s.u.)	8.1	7.2	--	7.65

The data in the above table was referenced from "Discharge Plan Application and Application for Authorization to Inject per Oil Conservation Division Form C-108, into Class I Wells WDW-1 and Proposed WDW-2 and WDW-3" and the "Discharge Permit Approval Conditions", "Reentry and Completion Report Waste Disposal Well No. 2", and "Reentry and Completion Report Waste Disposal Well No. 3".

TABLE II TABULATION OF WELLS WITHIN 1 MILE OF THE INJECTION WELLS

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
1	30-015-00693	GEORGE A CHASE & C SERVICE DELHI #001	36 17S 27E A 330N 330E	528	T/A O	8/30/1941
2	30-015-00694	DELHI OIL CORP. STATE #013	36 17S 27E A 990N 990E	1993	P&A O	6/24/1948 6/24/1948
3	30-015-00646	GEORGE A CHASE & C SERVICE DELHI #007	36 17S 27E A 990N 330E	540	T/A O	4/21/1950
4	30-015-00668	LEGACY RESERVES OPERATING, LP SOUTH RED LAKE GRAYBURG UNIT #010	36 17S 27E G 1650N 2310E	1736	SHUT IN O	12/6/1947
5	30-015-00690	GEORGE A CHASE & C SERVICE CONKLIN #002	36 17S 27E G 1830N 2205E	532	ACTIVE O	3/6/1949
6	30-015-00667	FAIRWAY RESOURCES OPERATING INC SOUTH RED LAKE GRAYBURG UNIT #011	36 17S 27E G 2310N 2310E	1733	ACTIVE I	3/23/1949
7	30-015-00666	GEORGE A CHASE & C SERVICE CONKLIN #001	36 17S 27E G 2310N 2310E	533	ACTIVE 1/12/10 P&A 9/10/07 O	1/10/1942 9/10/2007
8	30-015-00689	GEORGE A CHASE JR & C SERVICE GATES STATE #001	36 17S 27E H 1650N 330E	557	ACTIVE O	8/4/1950
9	30-015-00647	ASPEN OIL INC GATES STATE #002	36 17S 27E H 1650N 990E	551	ACTIVE O	10/21/2003 10/21/2003
10	30-015-00669	GEORGE A CHASE JR & C SERVICE HOMAN #001	36 17S 27E H 2310N 330E	1804	P&A O	5/6/2008 5/6/2008
11	30-015-00688	KERSEY & CO RAMAPO #001	36 17S 27E I 2310S 330E	590	P&A O	10/28/1941 10/28/1941
12	30-015-00670	KERSEY & CO RAMAPO #003	36 17S 27E I 2970N 330E	1857	P&A O	1/3/1950 1/3/1950
13	30-015-00687	KERSEY & CO RAMAPO #002	36 17S 27E I 2310S 990E	1900	P&A G	5/7/1948 5/7/1948

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
14	30-015-00685	ARCO OIL & GAS EMPIRE ABO UNIT G #020	36 17S 27E I 1650S 330E	5980	P&A O	7/10/1989 7/10/1989
15	30-015-00671	ROJO GRANDE COMPANY LLC RAMAPO #003	36 17S 27E J 2310S 2310E	591	ZONE ABAN O	2/13/1942 1/24/2000
16	30-015-01221	MCQUADRANGLE, LC SOUTH RED LAKE GRAYBURG UNIT #023	36 17S 27E J 2300S 2300E	1790	ZONE ABAN O	2/27/1948 8/13/2002
17		MARTIN YATES III DOOLEY STATE #3	36 17S 27E J	5865		4/22/1961
18	30-015-05934	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #019A	36 17S 27E J 1650S 1650E	5970	ACTIVE O	2/26/1961
19	30-015-01220	MCQUADRANGLE, LC SOUTH RED LAKE GRAYBURG UNIT #022	36 17S 27E K 2310S 2330W	1747	ZONE ABAN O	2/3/1949 7/17/2002
20	30-015-00674	ROJO GRANDE COMPANY LLC RAMAPO #002	36 17S 27E K 2310S 2310W	514	ACTIVE O	5/15/1947
21	30-015-01219	MCQUADRANGLE, LC SOUTH RED LAKE GRAYBURG UNIT #021	36 17S 27E K 2310S 1650W	1710	ACTIVE I	1/20/1948
22	30-015-23913	MCQUADRANGLE, LC SOUTH RED LAKE GRAYBURG UNIT #043	36 17S 27E K 1650S 1650W	1785	ACTIVE O	12/11/1981
23		MARTIN YATES III DOOLEY STATE ABO #3	36 17S 27E K	5865	ACTIVE O	4/19/1961
24	30-015-00673	ROJO GRANDE COMPANY LLC RAMAPO #001	36 17S 27E K 1650S 2310W	510	ZONE ABAN O	1/24/2000 1/24/2000
25	30-015-00682	ROJO GRANDE COMPANY LLC RAMAPO #004	36 17S 27E N 990S 1650W	541	ZONE ABAN O	1/24/2000 1/24/2000
26	30-015-00683	FAIRWAY RESOURCES OPERATING INC SOUTH RED LAKE GRAYBURG UNIT #028	36 17S 27E N 965S 1650W	1812	ACTIVE I	4/16/1948
27	30-015-01218	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #018	36 17S 27E N 330S 2310W	5925	P&A O	3/11/2009 3/11/2009

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
28	30-015-00684	BURNHAM OIL COMPANY STATE B-6961 NO. 1-A	36 17S 27E O 990S 2310E	1500	P&A O	5/13/1947 5/13/1947
29	30-015-01251	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #019	36 17S 27E O 660S 1980E	6200	P&A O	9/8/1959 4/27/2009
30			36 17S 27E I		MISPLOT OF 14	
31	30-015-00677	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #020	36 17S 27E P 330S 990E	6013	P&A O	4/13/2009 4/10/2009
32	30-015-01616	C F M OIL CO BLAKE STATE #001	30 17S 28E P 330S 990E	615	ACTIVE O	3/7/1953
33	30-015-01638	ALAMO PERMIAN RESOURCES LLC STATE NO. 1	31 17S 28E A 330N 990E	2004	ACTIVE O	7/15/1952 7/15/1952
34	30-015-21594	FINNEY OIL COMPANY POWCO STATE #001	31 17S 28E B 330N 1650E	652	ACTIVE O	11/15/1975
35	30-015-01636	BEDINGFIELD, J E DELHI-STATE NO. 1	31 17S 28E C 330N 2310E	637	P&A O	12/23/1952 12/23/1952
36	30-015-25621	FINNEY OIL COMPANY POWCO STATE #002	31 17S 28E B 980N 1620E	747	ACTIVE O	7/15/1986
37	30-015-01633	GEORGE A CHASE JR DBA G AND C SERVIC ASTON & FAIR A #001	31 17S 28E D 330N 330W	531	ACTIVE O	6/23/1942
38	30-015-01634	ASTON & FAIR STATE 31 NO. 1X	31 17S 28E D 350N 345W	525	NO COMPL O	1/5/1946
39	30-015-01645	MCLAUGHLIN, C T BEDINGFIELD STATE 1 NO. 1	31 17S 28E F 990N 990W	2307	P&A O	2/16/1950 2/16/1950
40	30-015-02666	DORAL ENERGY CORP. HUDSON SAIKIN STATE #001	31 17S 28E E 2310N 330W	1816	ACTIVE O	5/29/1948
41	30-015-24887	DORAL ENERGY CORP. HUDSON SAIKIN STATE #002	31 17S 28E E 2310N 990W	1950	ACTIVE O	7/7/1984

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
42	30-015-01643	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022	31 17S 28E F 2310N 2260W	5971	P&A O	6/7/1960 7/10/2009
43	30-015-01635	GEORGE A CHASE JR DBA G AND C SERVIC ASTON & FAIR #001Y	31 17S 28E F 2310N 2310W	1926	ACTIVE O	5/8/1948
44	30-015-01637	GEORGE A CHASE JR DBA G AND C SERVIC MALCO STATE #001	31 17S 28E G 2310N 2310E	1852	ACTIVE O	10/12/1953
45	30-015-01652	KERSEY & CO BOLING #001	31 17S 28E G 2288N 1625E	6025	ACTIVE O	8/10/1960
46	30-015-10537	VANGUARD OPERATING LLC NORTHWEST ARTESIA UNIT #004	31 17S 28E H 2277N 330E	6180	ACTIVE O	9/23/1965
47	30-015-10833	VANGUARD OPERATING LLC NORTHWEST ARTESIA UNIT #010	31 17S 28E I 1980S 660E	1945	ACTIVE O	6/17/1966
48	30-015-01644	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #024A	31 17S 28E I 1650S 330E	6106	P&A O	4/29/1960 6/12/2009
49	30-015-01642	DORAL ENERGY CORP. STATE FW #001	31 17S 28E J 1650S 2310E	1937	ACTIVE O	12/23/1962
50	30-015-01650	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #023A	31 17S 28E J 1650S 1958E	6094	P&A O	9/17/2003 9/17/2003
51	30-015-01651	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022B	31 17S 28E K 1650S 2387W	6046	P&A O	4/10/1960 10/22/2009
52	30-015-01640	DORAL ENERGY CORP. RAMPO #002	31 17S 28E L 2310S 330W	1996	ACTIVE O	7/16/1955
53	30-015-01648	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #021A	31 17S 28E L 1651S 1089E	5971	ZONE ABAN O	8/24/2002 8/24/2002
54	30-015-01639	DORAL ENERGY CORP. RAMPO #001	31 17S 28E M 990S 330W	1975	ACTIVE O	5/1/1948
55	30-015-01647	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #021	31 17S 28E M 660S 660W	6006	P&A O	1/31/1960 7/23/2005

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
56	30-015-01646	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022A	31 17S 28E N 660S 2082W	6050	P&A O	1/22/1960
57	30-015-10118	DORAL ENERGY CORP. STATE FV #001	31 17S 28E N 766S 2188W	1938	ACTIVE O	3/1/1963
58	30-015-01653	OTIS A ROBERTS PARKER-STATE NO. 1	31 17S 28E O 990S 1650E	742	P&A O	1/18/1942 1/18/1942
59	30-015-27592	NAVAJO REFINING CO. PIPELINE DIVISION WDW #001	31 17S 28E 660S 2310E	10200	ACTIVE I	8/4/1998
60	30-015-01649	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #023	31 17S 28E O 660S 1939E	6094	P&A O	2/24/1960 8/14/2009
61	30-015-20042	VANGUARD OPERATING LLC NORTHWEST ARTESIA UNIT #011	31 17S 28E P 990S 660E	2012	ACTIVE O	5/8/1967
62	30-015-01641	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #024	31 17S 28E P 660S 660E	6122	ACTIVE O	3/12/1960
63	30-015-01654	BEDINGFIELD, J E ASTON-STATE NO. 1	32 17S 28E D 330N 330W	651	P&A O	5/12/1953 5/12/1953
64	30-015-01671	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #025B	32 17S 28E E 2280N 978W	6013	P&A O	9/13/1960 8/14/2008
65	30-015-01657	MARBOB ENERGY CORP AA STATE NO. 1	32 17S 28E F 2280N 1980W	6171	ACTIVE O	8/24/1960
66	30-015-10818	SDX RESOURCES INC NORTHWEST ARTESIA UNIT #008	32 17S 28E K 2310S 2105W	2003	P&A O	11/6/2006 11/6/2006
67	30-015-01661	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #026B	32 17S 28E K 1650S 2310W	6083	ACTIVE O	3/27/1960
68	30-015-10795	LIME ROCK RESOURCES A, LP NORTHWEST ARTESIA UNIT #009	32 17S 28E L 2310S 660W	1930	P&A O	5/15/1966 5/28/2008
69	30-015-01662	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #025A	32 17S 28E L 1650S 990W	6075	ACTIVE O	4/13/1960

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
70	30-015-20043	VANGUARD OPERATING LLC NORTHWEST ARTESIA UNIT #012	32 17S 28E M 990S 760W	1998	ACTIVE O	5/9/1967
71	30-015-01660	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #025	32 17S 28E M 660S 660W	6132	P&A O	3/5/1960 1/14/2009
72	30-015-10834	SDX RESOURCES INC NORTHWEST ARTESIA UNIT #013	32 17S 28E N 990S 2030W	1954	P&A O	9/15/2006 9/15/2006
73	30-015-01659	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #026A	32 17S 28E N 660S 1980W	6172	ACTIVE O	2/14/1960
74	30-015-21539	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #261	32 17S 28E N 150S 1400W	6220	ACTIVE O	7/25/1975
75	30-015-22009	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #272	32 17S 28E O 330S 2481E	6370	ACTIVE O	7/18/1977
76	30-015-02606	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #026E	5 18S 28E C 330N 1941W	6254	ACTIVE O	7/18/1960
77	30-015-22697	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #261A	5 18S 28E C 1080N 1914W	6350	P&A O	1/4/1979 6/16/2009
78	30-015-02607	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #025C	5 18S 28E D 660N 660W	6273	ACTIVE O	3/27/1960
79	30-015-22750	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #251	5 18S 28E D 660N 150W	6250	SHUT IN O	1/12/1979
80	30-015-02608	CONOCOPHILLIPS COMPANY STATE E AI #001	5 18S 28E E 1660N 330W	6265	P&A O	1/13/2006 1/13/2006
81	30-015-24485	CONOCOPHILLIPS COMPANY ILLINOIS CAMP A COM #001	5 18S 28E E 1980N 990W	10450	ACTIVE G	8/10/1983
82	30-015-02602	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #026D	5 18S 28E F 1650N 1650W	6265	ACTIVE O	12/30/1959
83	30-015-25522	I & W INC WALTER SOLT STATE #001	5 18S 28E L 2240S 400W	8500	ACTIVE S	8/12/1983

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
84	30-015-10244	MACK ENERGY CORP STATE AG #001	5 18S 28E L 2310S 330W	6365	ZONE ABAN O	3/27/2001 3/27/2001
87	30-015-20019	LIME ROCK RESOURCES A, LP NORTHWEST ARTESIA UNIT #016	6 18S 28E A 330N 330E	3280	ACTIVE O	3/14/1967
88	30-015-02615	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #024B	6 18S 28E A 660N 660E	6241	ACTIVE O	2/29/1960
89	30-015-02625	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #023C	6 18S 28E B 470N 2170E	6194	T/A O	12/21/1959
90	30-015-21542	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #231	6 18S 28E B 1260N 1580E	6250	ACTIVE O	11/1/1975
91	30-015-02621	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022E	6 18S 28E C 660N 1980W	6033	ACTIVE O	12/29/1959
92	30-015-21626	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #231A	6 18S 28E G 1361N 2531E	6380	SHUT IN O	10/22/1975
93	30-015-02613	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #021B	6 18S 28E D 990N 660W	6119	ACTIVE O	12/30/1959
94	30-015-23116	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #213	6 18S 28E E 2050N 100W	6225	ACTIVE O	6/2/1980
95	30-015-02619	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #021C	6 18S 28E E 1990N 660W	6202	ACTIVE O	10/30/1959
96	30-015-22637	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #212	6 18S 28E E 2450N 400W	6267	ACTIVE O	12/28/1978
97	30-015-21395	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #211	6 18S 28E E 2630N 1300W	6200	ACTIVE O	2/11/1975
98	30-015-22012	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #222	6 18S 28E F 1350N 1572W	6303	ACTIVE O	3/13/1977
99	30-015-02626	SARKIN, DAVID C & OLIVER, HENRY F STATE NO. 1	6 18S 28E F 1650N 1650W	705	P&A O	2/21/1942 2/21/1942

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
100	30-015-10107	DORAL ENERGY CORP STATE FX #001	6 18S 28E F 1874N 1874W	1985	ACTIVE O	8/8/1963
101	30-015-02620	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022D	6 18S 28E F 1990N 2082W	6206	ACTIVE O	11/26/1959
102	30-015-22527	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #223	6 18S 28E F 2630N 1930W	6250	ACTIVE O	5/19/1978
103	30-015-21746	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #221	6 18S 28E F 2610N 2713W	6305	ACTIVE O	4/23/1976
104	30-015-22913	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #235	6 18S 28E G 1750N 1600E	6300	ACTIVE O	7/8/1979
105	30-015-22593	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #234	6 18S 28E G 1900N 2441E	6260	P&A O	8/27/1978 12/3/2008
106	30-015-02614	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #023B	6 18S 28E G 1980N 1980E	6242	ACTIVE O	1/26/1960
107	30-015-21737	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #232	6 18S 28E G 2253N 1576E	6345	P&A O	4/13/1976 5/7/2009
108			6 18S 28E H		MISPLOT OF 107	
109	30-015-22490	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #233	6 18S 28E G 2550N 2050E	6300	P&A O	6/5/1978 4/3/2009
110	30-015-02616	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #024C	6 18S 28E H 1650N 990E	6253	ACTIVE O	3/24/1960
111	30-015-23547	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #241	6 18S 28E H 1950N 660E	6386	P&A O	4/12/1981 9/19/2008
112	30-015-02617	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #024K	6 18S 28E I 2310S 990E	6350	P&A O	12/12/2002 12/12/2002
113	30-015-22528	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #232A	6 18S 28E J 2300S 1570E	6350	P&A O	2/5/1979 4/7/2009

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
114	30-015-02611	BARNEY COCKBURN STATE NO. 1	6 18S 28E J 2310S 2310E	2095	P&A O	8/15/1949 8/15/1949
115	30-015-02628	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #023D	6 18S 28E J 2260S 2270E	6310	ACTIVE O	5/23/1979
116	30-015-22491	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #231B	6 18S 28E J 1700S 2350E	6350	P&A O	8/13/1978 9/2/2009
117	30-015-02618	MILLER BROS OIL CO CAPITOL STATE NO. 1	6 18S 28E J 1647S 2076E	2396	P&A G	3/21/1955 3/21/1955
118	30-015-02623	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022F	6 18S 28E K 2248S 2075W	6210	ACTIVE O	2/22/1960
119			6 18S 28E K		MISPLOT	
120		NAVAJO REFINING COMPANY WDW-2 (ORIGINAL LOCATION)	6 18S 28E L			
121	30-015-02622	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #021D	6 18S 28E L 2219S 660W	6194	ACTIVE O	1/23/1960
122	30-015-23548	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #211A	6 18S 28E L 1950S 1000W	6312	ACTIVE O	7/17/1980
123	30-015-02627	RUTH OIL CO, LLC STATE M-AI #002	6 18S 28E M 949S 990W	6225	ACTIVE O	10/21/1960
124	30-015-26943	MEWBOURNE OIL CO CHALK BLUFF 6 STATE #001	6 18S 28E M 990S 730W	10200	ACTIVE G	4/16/1992
125	30-015-02610	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #022C	6 18S 28E N 955S 1750W	6243	ACTIVE O	8/5/1960
126	30-015-02624	PAN AMERICAN PETROLEUM CO STATE CD NO. 1	6 18S 28E O 968S 2270E	6412	P&A O	5/1/1961 5/1/1961
127	30-015-25503	DICKSON PETROLEUM CO KIMBERLY STATE NO. 1	6 18S 28E P 660S 330E	1750	P&A O	12/30/1985 12/30/1985

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
128	30-015-02612	D & H OIL CO STATE NO. 1	6 18S 28E P 330S 330E	2246	P&A O	5/13/1952 5/13/1952
129	30-015-01215	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #020D	1 18S 27E A 667N 666E	6118	ACTIVE O	11/5/1959
130	30-015-00708	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #019B	1 18S 27E B 660N 1980E	6078	ACTIVE O	7/7/1959
131		MALCO REFINERIES HILL #4	1 18S 27E C	1840	P&A	5/10/1948 5/10/1948
132			1 18S 27E C		MISPLOT	
133	30-015-00710	MARBOB ENERGY CORP AAO FEDERAL No. 013	1 18S 27E C 660N 1980W	6173	ACTIVE O	7/21/2004
134	30-015-26741	MEWBOURNE OIL CO CHALK BLUFF FEDERAL COM #002	1 18S 27E F 1650N 1350W	10140	ACTIVE G	8/24/1991
135	30-015-00706	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #018A	1 18S 27E F 2310N 1980W	6087	ACTIVE O	5/31/1959
136	30-015-00709	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #019C	1 18S 27E G 1980N 1980E	6205	ACTIVE O	8/2/1959
137			1 18S 27E G		MISPLOT	
138	30-015-21552	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #191	1 18S 27E G 2500N 2500E	6259	ACTIVE O	9/7/1975
139	30-015-00711	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #020C	1 18S 27E H 1980N 660E	6218	ACTIVE O	10/13/1959
140	30-015-21783	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #202	1 18S 27E H 2490N 1299E	6296	ACTIVE O	5/13/1976
141	30-015-22656	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #203	1 18S 27E H 2400N 700E	6225	ACTIVE O	10/10/1978

ID NO	API	OPERATOR, WELL NAME, NUMBER	SEC, TWP, RGE, UL	DEPTH	STATUS TYPE	COMP. DATE PLUG DATE
142		MANHATTAN OIL CRONIN #1	1 18S 27E H	2900	P&A	7/1/1927 7/1/2027
143	30-015-21553	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #201	1 18S 27E H 2501N 20E	6225	ACTIVE O	7/19/1975
144	30-015-27163	MEWBOURNE OIL CO CHALK BLUFF FEDERAL COM #003	1 18S 27E I 1980S 990E	10150	ACTIVE G	1/16/1993
145	30-015-00697	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #020K	1 18S 27E I 1980S 660E	6185	P&A O	1/5/2003 1/5/2003
146	30-015-22657	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #193	1 18S 27E J 2490S 2200E	6225	ACTIVE O	10/26/1978
147	30-015-00696	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #019Q	1 18S 27E J 1980S 1980E	6180	ACTIVE O	8/20/1959
148	30-015-22560	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #192	1 18S 27E J 220S 1390E	6250	ACTIVE O	6/25/1978
149	30-015-21873	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #191A	1 18S 27E J 1526S 1470E	6350	ACTIVE O	9/23/1976
150	30-015-22658	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #194	1 18S 27E J 1500S 2130E	6325	ACTIVE O	11/14/1978
151	30-015-22559	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #184	1 18S 27E K 2290S 2445W	6200	SHUT IN O	7/25/1978
152	30-015-22096	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #183	1 18S 27E K 2370S 1510W	6210	ACTIVE O	7/24/1977
153	30-015-21554	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #181	1 18S 27E K 1367S 1440W	6203	P&A O	4/17/2003 4/17/2003
154	30-015-00707	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #018B	1 18S 27E K 1980S 1980W	6163	ACTIVE O	5/22/1959
155	30-015-21792	BP AMERICA PRODUCTION COMPANY EMPIRE ABO UNIT #182	1 18S 27E K 1533S 2370W	6369	ACTIVE O	6/1/1976