Search Minerals Completes Successful Bench And Pilot Plant Program To Test Improvements In The Proprietary Direct Ree Extraction Process

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VANCOUVER, March 31, 2020 - Search Minerals Inc. (TSXV: SMY) (“Search” or the “Company”) is pleased to announce the final results from its bench and pilot plant testing operation at SGS Laboratories (“SGS”) in Lakefield, Ontario.

An extensive bench testing and pilot plant campaign has been completed at SGS to test engineering and process improvements in the Search Minerals Proprietary Direct Extraction Process.

Bench Testing and Pilot Plant Highlights:

- Tested new methods of acid/ore contact and heating using crushed Foxtrot Deposit material followed by water leaching.
- Achieved excellent metallurgical results including:
    - Best extraction of 87% Neodymium (Nd), 88% Praseodymium (Pr), 77% Dysprosium (Dy) and 78% Terbium (Tb) by acid treatment/water leaching of -0.5 mm crushed Foxtrot Deposit material at bench scale.
    - Effective removal of uranium from either the primary water leach solution or the secondary releach solution using ion exchange. Uranium was reduced to below detection limit in solution.
    - First precipitation of +99.9% of the rare earth elements as an intermediate mixed carbonate product
    - Demonstration of improved releaching process to reject more silica and aluminum from the rare earth sulfate solution prior to thorium removal.
    - Demonstration in bench and pilot plant testing of the removal of thorium from the secondary releach solution using a selective solvent extraction process. The solvent system is based on the Primene JMT primary amine extractant (commercially available). The process was tested in a 5-day continuous pilot plant comprising two stages each of extraction, scrubbing, and stripping, allowing for virtually 100% removal of thorium with minimal losses of rare earth elements to the thorium strip solution.
    - Demonstration of continuous removal of zinc by sulfide precipitation to less than 1 mg/L of zinc remaining in solution.
    - Oxalic acid precipitation of the rare earths followed by calcination to produce ~99% pure rare earth oxide product
    - As an alternative, the precipitation of a mixed rare earth carbonate with 58% REO content was demonstrated after supplemental removal of aluminum from the zinc free solution.
- Generated engineering data for all parts of the circuit from sample preparation to production of the mixed rare earth oxide.

Greg Andrews, President and Chief Executive Officer of Search, states, “The results from the pilot plant testing conducted at SGS Laboratories in Lakefield, Ontario have exceeded expectations. Search has now produced both a 58% REO mixed rare earth carbonate concentrate and a 99% pure mixed REO concentrate, which will provide Search with more options as we seek to refine our products into the individual oxides.”

Furthermore, “Search Minerals would like to acknowledge the funding from both Atlantic Canada Opportunities Agency (Federal) and InnovateNL (Newfoundland and Labrador). Their support, since 2014, has allowed Search to be at the forefront of the recent focus to create a secure rare earth supply chain for electric vehicles and wind turbines in North America and Europe.”

Further Description of Process and Results

The Search Minerals Direct Extraction Process was tested on a representative sample of Foxtrot mineralization (1% TREO) at SGS Minerals Lakefield Site.

Table 1. Foxtrot Bulk Sample Analysis

Element	Unit	Amount
La	g/t	1600
Ce	g/t	3410
Pr	g/t	408
Nd	g/t	1500
Sm	g/t	270
Eu	g/t	14.1
Gd	g/t	280
Tb	g/t	40.5
Dy	g/t	238
Ho	g/t	47
Y	g/t	1180
Er	g/t	131
Tm	g/t	17.8
Yb	g/t	111
Lu	g/t	15.7
Sc	g/t	<25
Th	g/t	151
U	g/t	31.9
Si	%	31.9
Al	%	3.92
Fe	%	7.42
Mg	%	0.3
Ca	%	2.05
Na	%	1.78
K	%	2.85
Ti	%	0.31
P	%	0.03
Mn	%	0.26
Cr	%	0.02
V	%	<0.01

Primary Leach Circuit

Acid Bake and Water Leach Optimization – Bench Scale

A study of acid baking and water leaching examined the impact of crush particle size prior to acid treatment, and % solids and temperature in the water leach. The acid bake conditions were; 150 kg/t of H_2SO_4 added versus 145 kg/t for Baseline test, heating to 190°C and holding at temperature for 4 hours.

Test 0 (Baseline) mimics the water leach conditions used historically with a coarser crush size (?1.7 mm). Tests 1 and 2 compare 80 and 90°C at 10% solids and Test 3 and 4 compare 80 and 90°C at 20% solids. The extraction is always improved at 90 °C. The light rare earth element leaching (La, Ce, Pr, Nd) is relatively unaffected by % solids in leach. However the Terbium and Dysprosium (Tb, Dy) extractions are reduced at 20% solids. The best extractions are achieved in Test 2 with 87% Neodymium (Nd), 88% Praseodymium (Pr), 77% Dysprosium (Dy) and 78% Terbium (Tb). These elements are the main value drivers for Foxtrot as they are used in magnet making for electric vehicle and related applications.

Table 2. Acid Bake and Water Leach Bench Tests

Test	0 (Baseline)	1	2	3	4
Particle Size	-1.7 mm	-0.5 mm	-0.5 mm	-0.5 mm	-0.5 mm
Water Leach % Solids	10	10	10	20	20
Water Leach Time (h)	36	24	24	24	24
Water Leach Temperature (°C)	90	80	90	80	90
Extraction (%)					
La	86	85	89	88	90
Ce	88	85	89	87	90
Pr	87	85	89	86	89
Nd	87	87	90	87	90
Sm	85	83	86	80	83
Eu	83	81	83	76	78
Gd	78	79	81	74	76
Tb	77	77	78	69	71
Dy	74	76	77	67	69
Ho	73	74	75	63	65
Y	74	74	76	68	68
Er	72	72	73	61	62
Tm	72	69	71	58	60
Yb	65	64	65	55	57
Lu	57	57	58	48	51
Th	79	77	74	87	87
U	52	53	53	53	52

A number of other tests were performed with wet grinding after acid baking and prior to water leaching. These showed only slight improvement in the rare earth element extractions. The addition of hot acid to hot ore and then mixing was compared to cold acid and cold ore mixing followed by heating and then in each case, water leaching. The results were comparable.

Acid Bake and Water Leach Optimization – Pilot Plant

Pre-crushed ore (-1.7 mm) was processed through a screw furnace to preheat the ore, which was then mixed with preheated sulphuric acid (both at or near 190°C) in a stainless steel pug mill. The heated acid and ore mixture was then transferred to a static oven set at 185°C for four hours to complete the acid bake.

While preheating of the separate materials was successful, significant material buildup and corrosion was observed in the pug mill, wearing down the paddles that sweep material down the trough to the discharge. This is likely a matter of materials of construction, as the SS316 grade paddles in the pug mill were of insufficient hardness and acid resistance to withstand such aggressive chemical and physical conditions. Additional vendor investigations were recommended by SGS for the engineering plant design phase of the Search project to ensure that the materials of construction and equipment configuration are appropriate for the process. Sulphur assays of the batches of acid-baked product generated in this campaign were in line with previous piloting and bench tests, suggesting that any additional acid losses as a result of thermal decomposition from preheating the acid beforehand were negligible.

The calcine produced in the acid bake campaign was then water leached in batches, maintained at 90°C for 36 hours at 10% solids. After 36 hours, the pulp was oxidized with hydrogen peroxide and then adjusted to pH 3.2 using magnesium carbonate slurry for two hours to precipitate most of the iron and thorium as hydroxides before filtering. This pilot plant campaign was simply a liquor production exercise to generate a bulk volume of solution for downstream testing. A total of approximately 6000 liters of solution containing approximately 800 mg/L TREE was produced from leaching of 730 kg of prepared calcine.

Water Leach Solution Treatment

The water leach solution was split in two. The first portion was treated by uranium ion exchange and then precipitated with sodium carbonate to make a rare earth carbonate precipitate for releaching and further purification. The second portion went directly to rare earth carbonate precipitation. The removal of uranium from this material was investigated as part of the releach circuit purification.

The uranium ion exchange test on the water leach solution removed uranium from 2 mg/L U to below the detection limit of 0.02 mg/L U (+99% removal) using Purolite A660 resin in two columns (lead and lag configuration) with each column containing ~5 L of resin. The treatment rate was 1 L/min which equated to 12.5 BV/h. A total of ~3000 L was treated in about 48 hours. The REE concentrations in the uranium free solution were unchanged from the influent solution, confirming highly selective uranium removal with negligible loss of REE.

The rare earth precipitation pilot plant was conducted at 50°C and pH 6.5 with 150 g/L Na_2CO_3 solution addition. The circuit was configured with three tanks overflowing in series with the last tank flow directed to a thickener. The thickener underflow was filtered and washed. The recovery of rare earth elements to the precipitate was essentially 100% along with any thorium, uranium, aluminum, iron, zinc, magnesium, and calcium present. Manganese recovery to the precipitate was controlled to about 10% total to allow separation of rare earths from manganese in solution. The rare earth carbonate precipitate analyses from the two solutions (with and without uranium removal prior to precipitation) are shown below.

Table 3. Analysis of the Rare Earth Carbonate Precipitates

	Analysis (%)									
Element	La	Ce	[illegible]	Dy	Ho	Y	Er	Tm	Yb	Lu
U-Cont. RE Carbonate	4.14	9.01	[illegible]	0.54	0.10	2.53	0.28	0.04	0.21	0.03
	Th	U	[illegible]	Zn						
	0.03	0.04	[illegible]	3.39						
Element	La	Ce	[illegible]	Dy	Ho	Y	Er	Tm	Yb	Lu
U-Free RE Carbonate	3.95	8.57	[illegible]	0.50	0.10	2.40	0.27	0.04	0.21	0.03
	Th	U	[illegible]	Zn						
	0.04	0.00	[illegible]	3.14						

Secondary Leach Circuit

Rare Earth Carbonate Releaching

The rare earth carbonate releaching is the start of the second part of the Search Minerals Direct Extraction Process circuit. The purpose is to re-dissolve the rare earth carbonate to the maximum extent while rejecting silicon and aluminum into the releach residue. The releach residue carrying minor amounts of rare earths is then returned to the acid bake and water leach circuit for secondary leaching to ensure high overall recovery of REE's. The procedure adopted involved re-dissolving the rare earths at pH 1 using sulfuric acid and then increasing the pH to 3.0 to 3.5 with magnesium carbonate addition to remove reprecipitated impurities. The higher the pH the greater the rejection of silicon and aluminum to the residue. Two bulk releach tests were performed on the rare earth carbonate precipitates. The analysis of the final releach solutions is shown below in Table 4. The Si level in solution was reduced to 28-46 mg/L in the releach solution representing over 99% rejection of Si to the solid residue.

Table 4. Bulk Releach Solution Analysis for Uranium-Containing RE Carbonate and Uranium-Free RE Carbonate

	Solution Analysis (mg/L)													
Element	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Y	Er	Tm	Yb	Lu
U-Cont RE Carbonate	3170	7060	819	3040	542	29	444	66	384	73	2020	203	27	168	21
U-Free RE Carbonate	3110	6950	810	3000	533	27	419	62	363	68	1970	191	26	163	20
Element	Th	U	Si	Al	Fe	Mg	Ca	Na	Mn	Zn					
U-Cont RE Carbonate	2.96	32	28	1630	6	9720	1610	253	330	2500					

U-Free RE Carbonate	7.32	0.05	46	2790	16	11600	1810	334	321	2390

The uranium containing releach solution was subjected to uranium ion exchange in the same manner as described previously. Uranium was removed from 32 mg/L to below the detection limit of 0.02 mg/L U in solution representing an efficiency of more than 99.9%.

Thorium Removal from Uranium-Free Releach Solution

The original process for thorium removal from the releach solution involved pH adjustment with magnesium carbonate to precipitate the thorium to low levels. This resulted in significant co-precipitation of REE’s. As this precipitate was to be returned to the acid bake/water leach circuit, the result was a large circulating load of REE’s and increased costs for acid (H_2SO_4) and base (Na_2CO_3) with each cycle.

Thorium removal using ion exchange and solvent extraction was investigated in this program. Ion exchange was not successful in removing thorium to less than 0.1 mg/L in solution. This was the level required to ensure less than 5 g/t Th in the mixed rare earth oxide produced from the final Th-free solution. Solvent extraction was tested first at the bench scale and then in a continuous pilot plant. The best results were achieved with a solvent extraction organic solution containing 1.0% Primene JMT (a primary amine), 2.5% isodecanol (a modifier) and 96.5% Aromatic 150ND (a diluent). A continuous pilot plant was used to demonstrate the removal of thorium away from rare earths. The following design parameters were used.

Aqueous Solution: Combined releach solution after uranium removal by ion exchange adjusted to pH 1.5.

Extraction: 2 stages at an A/O advance ratio of 5:1, maintained at 45°C

Scrubbing: 2 stages at an A/O advance ratio of 0.5:1 and an A/O mixer-settler ratio of 1:1, at ambient temperature. The scrub solution was 24 g/L H_2SO_4.

Stripping: 2 stages at an A/O advance ratio of 1.25:1 and an A/O mixer-settler ratio of 1:1 at ambient temperature. The strip solution was 18 g/L HCl.

The pilot plant ran for a total of 5 days and consistently removed the thorium from solution from 4.72 mg/L to <0.03 mg/L in the purified raffinate. This result easily exceeded the target of <0.1 mg/L of Th to achieve low Th in the final mixed rare earth product.

The losses of rare earths to the final strip solution have been estimated using the profile of the assays from the pilot plant circuit shown below. Each of the aqueous and organic liquids present in the pilot plant circuit was sampled and analyzed. Virtually 100% of the thorium is extracted and reports to the strip solution (Strip 1 Aqueous Solution). Meanwhile, the rare earths are weakly extracted, partially scrubbed, and report at low concentrations in the strip solution (Strip 1 Aqueous Solution). The fraction of the rare earths to the strip solution is always less than 1%. The strip solution can be returned directly to the water leach process or neutralized and the solid precipitate containing rare earth elements returned to the acid bake-water leach process to ensure that even the small amount of rare earths in the strip solution is recovered and the thorium is reprecipitated into the stable primary solid residue.

Table 5. Analysis of all Aqueous and Organic Solutions at the end of the Thorium Solvent Extraction Pilot Plant

	Aqueous Concentration (mg/L)							Organic Solution (mg/L)						Fraction to Strip
	Ext Feed	Ext 1	Ext 2	Scrub 1	Scrub 2	Strip 1	Strip 2	Ext 1	Ext 2	Scrub 1	Scrub 2	Strip 1	Strip 2	
La	3060	2670	2660	62.2	15.4	70.1	0.26	76	74	47	40	<3	<3	0.32%
Ce	6550	5670	5720	152	41.5	329	1.3	363	261	198	182	<3	<3	0.70%
Pr	758	658	663	18.5	5.12	43.2	0.16	35	34	26	24	<3	<3	0.79%
Nd	2730	2400	2420	68	19	135	0.48	119	117	88	80	<9	<9	0.69%
Sm	459	468	463	11	2.99	20.2	0.07	18	18	13	11	<4	<4	0.61%

Eu	27.2	23	23.3	0.52	0.14	0.74	<0.03	<3	<3	<3	<3	<3	<3	0.38%
Gd	464	420	426	8.8	2.17	7.4	<0.03	8	8	4	3	<3	<3	0.22%
Tb	71.1	64.6	64.9	1.36	0.33	1.08	<0.03	<3	<3	<3	<3	<3	<3	0.21%
Dy	412	371	376	7.47	1.77	4.96	<0.05	6	6	<4	<4	<4	<4	0.17%
Ho	79.3	71.5	72.1	1.36	0.3	0.62	<0.02	<2	<2	<2	<2	<2	<2	0.11%
Y	1750	1610	1540	27	5.3	6.48	0.03	18	18	6	3	<1	<1	0.05%
Er	214	191	193	3.53	0.74	1.28	<0.04	<4	<4	<4	<3	<4	<4	0.08%
Tm	29.6	26	25.9	0.49	0.1	0.16	<0.04	<4	<4	<4	<3	<4	<4	0.08%
Yb	164	149	147	2.85	0.58	0.91	<0.02	2	2	<2	<2	<2	<2	0.08%
Lu	21	18.8	18.9	0.34	0.06	0.08	<0.03	<3	<3	<3	<3	<3	<3	0.05%
Th	4.72	0.04	<0.03	<0.03	<0.07	34	0.8	<3	20	20	21	<3	<3	100.00%
U	0.03	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<2	<2	<2	<2	<2	<2	
Al	2080	1910	1910	<0.8	<0.8	<0.8	<0.8	31	32	29	31	25	27	
Fe	9	8.2	8.3	0.3	<0.2	0.8	<0.2	2	<1	<1	<1	<1	<1	
Mg	10500	9640	9640	2.23	0.72	0.26	0.29	<1	<1	<1	<1	<1	<1	
Ca	1290	1240	1210	<9	<9	<9	<9	9	10	9	10	9	9	
Na	290	257	260	<2	<2	<2	<2							
Mn	319	289	290	0.12	<0.04	<0.04	<0.04	<0.4	<0.4	<0.4	<0.3	<0.4	<0.4	
Zn	2450	2280	2270	<0.7	<0.8	<0.9	<0.10	<6	<6	<6	<6	<6	<6	

The thorium removal circuit was stable and well behaved throughout the pilot plant test. The organic solution was repeatedly recycled and showed no signs of chemical degradation or fouling by any chemical species. The use of thorium solvent extraction is a major improvement over the original pH adjustment method used in the first process pilot plant (2016) for thorium precipitation. Thorium solvent extraction will be adapted into future process designs for the Search Minerals Direct Extraction Process.

Zinc Precipitation

Zinc precipitation from the thorium free rare earth solution was demonstrated in a continuous pilot plant using hydrogen sulfide gas to form zinc sulfide precipitate. Zinc was removed to less than 1 mg/L by this method in a 3 stage circuit by adjustment of the starting solution to pH 2 and 50 C. The zinc precipitate analyzed 61% Zn and had negligible losses of REE’s.

Rare Earth Precipitation

The standard method of rare earth recovery from the purified solution (free of thorium and zinc) is to precipitate a mixed rare earth oxalate using oxalic acid and then calcine the precipitate to form a mixed rare earth oxide product.

The precipitation process was performed in batch mode with 40 L of solution at 50°C with addition of 125% of stoichiometric addition of oxalic acid (added as a 10% solution). The precipitate was filtered and washed and then calcined at 1200°C in a muffle furnace to produce the mixed rare earth oxide.

The analysis of the final mixed rare earth oxide was 99% REO (based on 100% - impurity content as oxides) as expected with 1 g/t Th and <0.5 g/t U. The quality of this product is consistent with the use of uranium ion exchange and the newly developed thorium solvent extraction process to remove thorium to very low levels.

Table 6. Analysis of the Mixed Rare Earth Oxide Product from the SGS 2019 Program

Element	Units	Assay
La	%	12.0
Ce	%	32.4
Pr	%	4.05

Nd	%	15.9
Sm	%	2.27
Eu	%	0.135
Gd	%	2.03
Tb	%	0.304
Dy	%	1.67
Ho	%	0.32
Y	%	7.52
Er	%	0.86
Tm	%	0.11
Yb	%	0.69
Lu	%	0.08
Sc	g/t	<40
Th	g/t	1
U	g/t	<0.5
Si	g/t	500
Al	g/t	<100
Fe	g/t	<100
Mg	g/t	1400
Ca	g/t	600
K	g/t	<100
Ti	g/t	<100
P	g/t	<100
Mn	g/t	<100
Zn	g/t	<40
S	%	0.27
C	%	<0.01
F	%	0.018
TREO*	%	99

The production of an alternative material was also tested. The formation of a mixed rare earth carbonate product from the thorium and zinc free solution was tested in two steps. In the first step, additional aluminum was removed from solution using pH adjustment with magnesium carbonate to pH ~5. The purified solution was then treated to pH 6.5 with sodium carbonate solution. All precipitation was performed at 50°C in batch mode.

The mixed carbonate product quality is shown below. The mixed rare earth content was approximately 58% total rare earth oxide (TREO) with very low levels of U and Th as expected based on the purification of the solution by the ion exchange and solvent extraction process.

Table 7. Mixed Carbonate Analysis (Dry Basis) with both Elemental and Oxide Equivalent Analysis for Rare Earth Elements

La	%	10.7	La_2O_3	%	12.6
Ce	%	16.0	CeO_2	%	19.6
Pr	%	2.24	Pr_6O_{11}	%	2.71
Nd	%	8.21	Nd_2O_3	%	9.58
Sm	%	1.31	Sm_2O_3	%	1.52
Eu	%	0.07	Eu_2O_3	%	0.08
Gd	%	1.23	Gd_2O_3	%	1.42
Tb	%	0.19	Tb_4O_7	%	0.22
Dy	%	1.06	Dy_2O_3	%	1.22
Ho	%	0.22	Ho_2O_3	%	0.25

Y	%	6.03	Y_2O_3	%	7.66
Er	%	0.57	Er_2O_3	%	0.66
Tm	%	0.07	Tm_2O_3	%	0.08
Yb	%	0.36	Yb_2O_3	%	0.41
Lu	%	0.04	Lu_2O_3	%	0.05
TREE	%	48.29	TREO	%	58.0
Sc	g/t	<40			
Th	g/t	0.7			
U	g/t	1.1			
Si	%	<0.07			
Al	%	0.06			
Fe	%	<0.0004			
Mg	%	0.62			
Ca	%	0.58			
Na	%	0.1			
K	%	<0.02			
Ti	%	0.003			
P	%	<0.004			
Mn	%	0.22			
Zn	%	0.007			
S	%	1.52			
F	%	0.72			

Summary

The bench and pilot plant program have successfully demonstrated improvements in various steps in the Search Minerals Direct Extraction Process.

1. The method of acid-ore mixing was tested using preheating of ore and acid followed by mixing. The rare earth extraction was unaffected by this new method of ore contact. The hot/acid ore mixing method continues to require focussed engineering efforts to minimize wear and maintain throughput. This will be taken up by the engineering team at the next stage of process design.
2. Achieved excellent metallurgical results including:
    - Extraction of 87% Neodymium (Nd), 88% Praseodymium (Pr), 77% Dysprosium (Dy) and 78% Terbium (Tb) by acid treatment/water leaching of -0.5 mm crushed Foxtrot Deposit material.
    - Effective removal of uranium from either the primary water leach solution or the secondary releach solution using ion exchange. Uranium was reduced to below detection limit in solution.
    - First precipitation of +99.9% of the rare earth elements as an intermediate mixed carbonate product
    - Demonstration of improved releaching process to increase rejection of silica and aluminum from the rare earth sulfate solution prior to thorium removal.
    - Demonstration in bench and pilot plant testing of the removal of thorium from the secondary releach solution using a selective solvent extraction process. The solvent system is based on the Primene JMT primary amine extractant (commercially available). The process was tested in a 5-day continuous pilot plant comprising two stages each of extraction, scrubbing and stripping allowed for virtually 100% removal of thorium with minimal losses of rare earth elements to the thorium strip solution.
    - Demonstration of continuous removal of zinc by sulfide precipitation to less than 1 mg/L of zinc remaining in solution.
    - Oxalic acid precipitation of the rare earths followed by calcination to produce ~99% pure rare earth oxide product
    - As an alternative, the precipitation of a mixed rare earth carbonate with 58% REO content was demonstrated after supplemental removal of aluminum from the zinc free solution.

- Generated engineering data for all parts of the circuit from sample preparation to production of the mixed rare earth oxide.

Qualified Person:

Dr. David Dreisinger, Ph.D., P.Eng., is the Company’s Vice President, Metallurgy and Qualified Person for the purposes of NI 43-101. Dr. Dreisinger has reviewed and approved the technical disclosure contained in this news release as applicable. The company will endeavour to meet high standards of integrity, transparency, and consistency in reporting technical content, including geological and assay (e.g., REE) data.

About Search Minerals Inc.

Led by a proven management team and board of directors, Search is focused on finding and developing resources within the emerging Critical Rare Earth Element (“CREE”) District of South East Labrador. The Company controls a belt 70 km long and 8 km wide including its 100% interest in the FOXTROT and DEEP FOX Projects, which are road accessible and at tidewater. Exploration efforts have advanced “Fox Meadow” as a new CREE prospect very similar to and in close proximity to FOXTROT and DEEP FOX. The FOXTROT Project has a capital cost to bring the initial project into production ($152 M – 2016 PEA for 1000 tpd of ore treatment), a short payback period and is scalable due to Search’s proprietary processing technology.

All material information on the Company may be found on its website at www.searchminerals.ca and on SEDAR at www.sedar.com

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