

- · Simultaneous Measurement
- · Lowest Carbon Footprint
- Smallest Laboratory Footprint

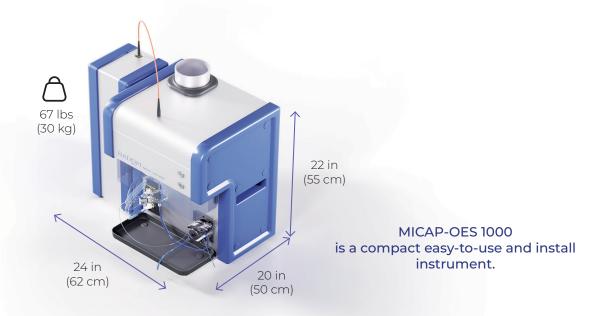


Figure 1: MICAP-OES 1000 Dimensions. Small, light-weight design made possible by Cerawave

Radom Corporation developed the solution for onsite instrumentation with Microwave Inductively Coupled Atmospheric Plasma – Optical Emission Spectrometer with 1000W power. This innovative nitrogen-based plasma atomic spectroscopy instrument replaces the traditional argon generated plasma technology.

MICAP-OES 1000 uses highly efficient Cerawave technology which eliminates the electric water-cooled coil found in commercially available ICP-OES

instruments today. Cerawave does not need water or air cooling and nitrogen is less expensive than argon. The power of Cerawave technology, coupled with a high-resolution echelle polychromator with CMOS detector, provides simultaneous measurement of elements in the prepared sample. The ability to screen core samples on location means results can be determined more quickly. An added benefit is the ability to collect more samples in an area to create a comprehensive map of the potential yield.

Table 1. Sample Introduction Area (SIA)

Autosampler	Teledyne Cetac Technologies ASX-560
Sample Tubing	Black/black PVC 0.76 mm ID
Drain Tubing	Yellow/blue PVC 1.52 mm ID
Nebulizer	Low-flow quartz nebulizer 1.0 mL/min
Spray chamber	Single pass cyclonic
Torch	20 mm quartz torch with 1.5 mm injector

The axial plasma view is made reproducible by the automatic plasma tail removal system that is comprised of the torch installation guide and alignment peg system.







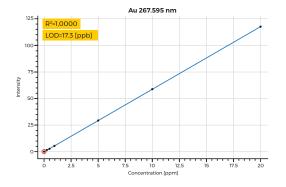
1. Torch guide

2. Torch alignment pegs

3. Completed assembly

Figure 2: Torch installation assembly





Typical calibration curve for gold (wavelength 267.595 nm) standardized from 0.025 ppm to 20 ppm displays the correlation coefficient as R2 and the calculated LOD.

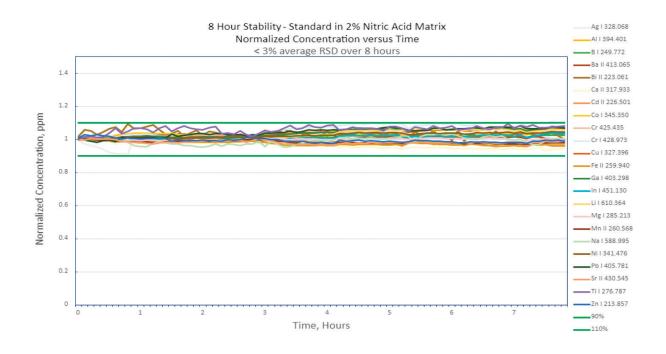
Results and Discussion

The CRM ID listed in the Table 2 summary provides certified results for gold based on statistical results submitted from participating laboratories. The certificate provides gold certification with preparation of ore by Pb (lead) fire assay, 4-acid digestion, aqua regia and cyanide leach. The study performed with MICAP-OES 1000 was aqua regia preparation only. According to the certificates, the aqua regia digestion participants use ICP-OES, ICP-MS and AAS to report the gold values in the ore.

The CRMs were prepared in duplicate and no additional dilution was required from the digested preparation of 2g to 50mL.

Table 2. OREAS CRM Results for Gold in Aqua Regia Digestions

Analyte	Wavelength	CRM ID	Certified Value	Preparation 1	Preparation 2	Dilution	Recoveryl	Recovery2
Au, ppm		238	2.95	2.99	2.84	1x	101%	96%
		242	8.33	6.95	7.28	lх	83%	87%
	267.595	255b	4.08	3.82	3.77	lх	94%	92%
		256b	7.58	7.61	7.13	٦x	100%	94%
		257b	14.17	14.55	15.42	lх	103%	109%





NEW POSSIBILITIES

- Powered by proprietary Cerawave technology
- Smallest and lightest instrument on the market
- Easy set up (box-to-bench in less than one hour!)
- Works with local nitrogen generation
- Lower service maintenance
- Higher operational efficiency
- Lower ownership cost (pays for itself in less than 3 years!)
- Lower carbon footprint

SERVICE MAINTENANCE ADVANTAGE

- NO maintenance required for RF generators/coils, detector or optical alignment, chiller malfunction (overheating or not in well-ventilated area) MICAP does not have these!
- Simple, easy maintenance by end-user of peristaltic pump and fiber optic connection no more waiting for service engineers!
- \$ 2 year warranty vs. typical 1 year warranty
- Service Package -1st year includes user replaceable components (peristaltic pump, fiber optic cable, collimator, and second Starter Kit)

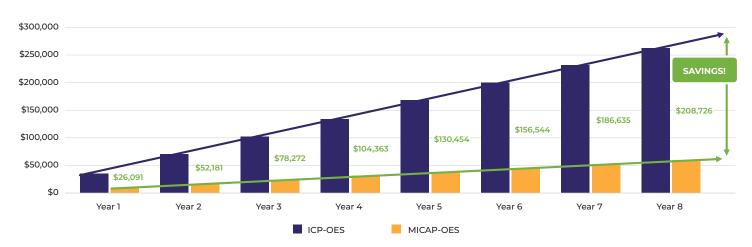
It's better for your lab and for the environment!

ANNUAL OWNERSHIP COST

	ICP-OES	MICAP-OES
Year 1	\$109,836	\$82,067
Year 2	\$33,336	\$7,067
Year 3	\$33,336	\$7,067
Total cost:	\$176,508	\$96,200
	Cost savings:	\$80,308

3-year total cumulative cost savings of \$80,308 over traditional ICP-OES!

CUMULATIVE COST SAVINGS



Total cumulative cost savings of \$208,726 over argon-based ICP-OES!



MICAP-OES 1000 saves 1,256 Metric tons of CO₂e over 8 years. It has the lowest carbon footprint of any OES instrument in the market!

LIFETIME CO₂e EMISSIONS SAVINGS COMPARED TO ARGON-BASED INSTRUMENTS

	kWh saved	1,772,540
	Metric tons of CO ₂ e saved*	1,256
	Equivalent to:	
a ^ö	Homes' annual electricity use	244
4	Gasoline-powered passenger vehicles	280
	Total gallons of gasoline consumed	141,357
<u> </u>	Total smartphones charged	152,812,225

*Based on 8-year useful-life. Source: EPA.GOV (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.)



FASTER AND SIMPLER ANALYSIS



Safer - eliminates the need for combustible gases and potential for flashback



No optimization of fuel/oxidant ratios, burner height or rotation which can be subjective to individual users



Simultaneous elemental measurements in less than 3 minutes/sample (3 replicates)



Full wavelength spectrum analysis and simultaneous measurement



Library of emission lines for minimization of interferences and result confirmation



Less sample preparation, less chemistry, and less consumables required

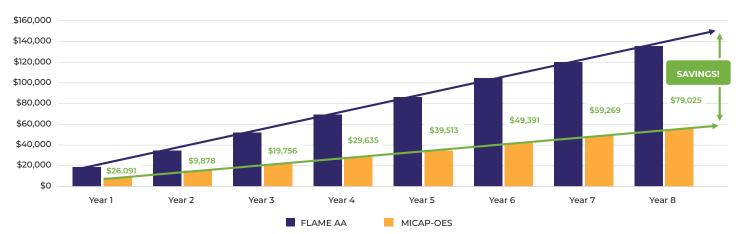
Analysis Time Considerations	Flame AA	MICAP-OES
Number of elements	7	7
Number of solutions	35	35
Time per sample analysis for 3 replicates	40 sec	2.3 minutes
Burner/fuel/lamp optimization and warmup time	30 min	20 min
Time per sample analysis for 3 replicates	20 min	20 min
Preparation time (6 elements)	2 hr	-
Instrument setup/warmup time (6 elements)	3 hr	-
Analysis time (6 elements)	<u>3 hr</u>	<u>2 hr</u>
Total	8 hr	2 hr

ANNUAL CONSUMABLE COST COMPARISON



MICAP-OES 1000 is 4x faster than Flame AA! MICAP-OES 1000 saves \$5,100 per year on consumables!

CUMULATIVE COST SAVINGS



Total cumulative cost savings of \$79,025 over traditional Flame AA!



- Major Gold Mining Company User, US

I can see the MICAP-OES system used on oil platforms.

- Danish Offshore Technology Centre

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Cerawave improves plasma robustness ... improves detection capabilities.

Laser ablation on the front of this OES instrument is likely a good solution for mine solid sampling in the field.

- University of Gothenburg, Sweden

- Alicante University, Spain

MICAP - OES 1000 Typical Limit of Detection and Resolution

∞ ▶

² He	HELIUM	10	S		NEON	18 Ar	ARGON	36	KRYPTON	Xe Xe	XENON	Bn Bn	RADON	118 Og	OGANESSON	71 261,542mm LU	LOD < 2 ppb LUTETIUM	103 Lr	LAWRENCIUM
7	≥ ►	0	Щ	r i	FLUUMINE	17 CI	CHLORINE	35 B	BROMINE	53	IODINE	85 At	ASTATINE	117 TS	TENNESSINE	70 328.938mm Yb	LOD <5 ppb YTTERBIUM	102 No	NOBELIUM
9	0 ▶	α	0	11101010	OAYGEN	16 S	SULFUR	34 196.036mm Se	LOD < 1 ppm SELENIUM	52 238,78nm Te	LOD < 330 ppb TELLURIUM	84 Po	POLONIUM	116 Lv	LIVERMORIUM	69 317282nm	LOD < 3 ppb THULIUM	101 Md	MENDELEVIUM
L L	<u>Ω</u> ►	7	Z	i man	MIROGEN	15 x3.362mm	LOD < 300 ppb PHOSPHORUS	33 assitem	LOD < 520 ppb ARSENIC	51 AB JOS	LOD < 300 ppb ANTIMONY	83 36,772mm	BISMUTH	115 MC	MOSCOVIUM	68 369.265mm	LOD < 5 ppb ERBIUM	100 Fm	FERMIUM
7	<u>+</u> ►	ď	S	10000	CARBOIN	14 251.61hm Si	LOD < 15 ppb SILICON	32 ASS.117nm Ge	LOD < 66 ppb GERMANIUM	50 283.997mm Sn	LOD < 78 ppb TIN	82 283.306mm Pb	LOD < 100 ppp	114 FI	FLEROVIUM	67 404.547mm HO	LOD < 10 ppb HOLMIUM	99 ES	EINSTEINIUM
Ç	<u></u> ▶	۲	m	L00 < 20 ppb	BURUN	13 396.152mm	LOD < 8 ppb ALUMINIUM	31 403.299mm Ga	LOD < 180 ppb GALLIUM	49 451.131nm	LOD < 97 ppb INDIUM	81 276.789mm	THALLIUM	113 Nh	NIHONINM	66 400,045mm	LOD < 7 ppb DYSPROSIUM	98 C	CALIFORNIUM
						10	. ▶	30 28.858mm Zn	LOD < 60 ppb ZINC	48 233.301nm Cd	LOD < 42 ppb CADMIUM	80 x3.651mm	MERCURY	112 Cn	COPERNICIUM	65 sc. Amm	LOD < 10 ppb TERBIUM	97 Bk	BERKELIUM
ion						-	>	29 324.754em	LOD < 13 ppb COPPER	47 38.067mm Ag	LOD < 5 ppb SILVER	79 242.79 Sem AU	GOLD 60LD	Hg Rg	ROENTGENIUM	64 418.42hm	LOD < 4 ppb GADOLINIUM	96 Cm	CURIUM
Resolution	5	E	71	21	30	10	2 ▶	28 341,475nm	LOD < 85 ppb NICKEL	46 340,457mm Pd	LOD < 13 ppb PALLADIUM	78 29,796mm Pt	PLATINUM	110 DS	DARMSTADTIUM	63 420.305mm EU	LOD < 2 ppb EUROPIUM	95 Am	AMERICIUM
						6) >	27 23.892nm Co	LOD < 26 ppb COBALT	45 437481nm Rh	LOD < 13 ppb RHODIUM	77 284.973 mm	IRIDIUM	109 Mt	MEITNERIUM	62 43.301nm Sm	LOD <2 ppb SAMARIUM	94 Pu	PLUTONIUM
ا ل ال	Zn 202.584	Cr 360.534	Ba 455.403	Na 588.996	Li 610.364	oc	> ►	26 359.338nm Fe	LOD < 22 ppb IRON	44 366.136em Bu	LOD < 4 ppb RUTHENIUM	76 42.047nm OS	WOIMSO NOT	108 HS	HASSIUM	В	PROMETHIUM	93 Np	NEPTUNIUM
	ZuZ	Cr 3	Ba,	e Z	Li 6	_		25 259.372mm Mn	LOD < 10 ppb MANGANESE	43 TC	TECHNETIUM	75 346.048mm	RHENIUM	107 Bh	BOHRIUM	60 430.358mm	LOD < 6 ppb NEODYMIUM	92 424.167mm	LOD < 50 ppb URANIUM
	Typical S	olution				c	> ▶	24 283563nm Cr	LOD < 22 ppb CHROMIUM	42 386,410em MO	LOD < 62 ppb MOLYBDENUM	74 40.874mm W	TUNGSTEN	106 Sg	SEABORGIUM	59 440.883.nm	LOD < 3 ppb PRASEODYMIUM	Pa Pa	PROTACTINIUM
	Typical Typical MICAP-OFS 1000	Res				ις	> ▶	23 399310nm V	LOD < 16 ppb VANADIUM	41 365.118am	LOD < 11 ppb NIOBIUM	73 296.514mm	TANTALUM	105 Db	DUBNIUM	58 48.993mm	LOD < 50 ppb CERIUM	90 A8.186mm	LOD < 17 ppb THORIUM
						4	- ▶	22 334,940mm	LOD < 2 ppb TITANIUM	40 283 Seam Zr	LOD < 4 ppb ZIRCONIUM	72 301.299nm Hf	HAFNIUM	104 Rf	RUTHERFORDIUM	57 432.29em	LOD < 2 ppb LANTHANIUM	AC AC	ACTINIUM
						en	> ▶	21 38.073mm Sc	LOD < 3 ppb SCANDIUM	39 A37,492mm	LOD < 2 ppb YTTRIUM	•		•		•		•	
c	V Þ	<	Be	100 < 2 ppb	BERYLLIUM	12 230,270am Mg	LOD < 2 ppb MAGNESIUM	20 393366em Ca	LOD < 1 ppb CALCIUM	38 407.772am	LOD < 1 ppb STRONTIUM	56 455.488mm Ba	BARIUM	Ra Ba	RADIUM	-5	Lantilainue series	Actinide series	
I	HYDROGEN	۲		9	LIMOM		LOD < 7 ppb	19 766.490mm	LOD < 10 ppb POTASSIUM	37 Rb	RUBIDIUM	55 CS	CESIUM	87 Fr	FRANCIUM	-	rqui	Actir	
			6	7		≜		4		5		9							

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