



**RESUMÉ: STEVEN WEBSTER**

Mr. Steven Webster, Hydrometallurgist and Solvent Extraction Specialist, with 29 years experience in the development of innovative hydrometallurgical processes, founded SX Kinetics, Inc., a technology firm specializing in providing “turn-key” solvent extraction and electrowinning pilot plants with technical consulting services.

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### **PROJECT MANAGEMENT**

- Prepared research proposals, budgets, and cost estimates
- Controlled project costs and implemented a fixed price budget system
- Planned and executed test programs at the laboratory and pilot plant scales
- Wrote research reports, procedures and technical papers
- Attended conferences, workshops, and short courses
- Reported to senior technical personnel, clients and supervised technicians

### **TECHNOLOGY**

- Performed a technical review on a rare earth solvent extraction plant in China
- Assisted in a technical audit of a cobalt solvent extraction plant
- Designed, and manufactured turn-key solvent extraction plants (pilot, demo, and production plant scales)
- Developed solvent extraction technologies for rare earth separation
- Prepared operating procedures and equipment manuals for solvent extraction plants
- Developed a process to recover cobalt from lab tests through to plant construction
- Assisted in the operation a 600,000 lb/year cobalt solvent extraction plant
- Prepared P& ID's and mass balance tables for a lutetium / cerium solvent extraction circuit
- Supervised the start up of uranium, tantalum, and scandium solvent extraction plants
- Assisted in the start up of a cobalt/nickel hydrometallurgical plant that included cobalt solvent extraction
- Conceived and developed various hydrometallurgical flowsheets
- Designed, constructed, and operated various hydrometallurgical pilot and demo plants
- Acquired extensive solvent extraction experience for a wide variety of metals
- Implemented solvent extraction procedures for bench and pilot plant testing
- Designed experiments to ensure reproducibility and good material balances

## EDUCATION

Loyalist College, Belleville, Ontario  
Chemical Engineering Technology  
Graduated in 1979

## PUBLICATIONS AND PATENTS

Nickel/Cobalt Recovery from Uranium Raffinate Solution  
A.R. Marchbank, L.A. Melis and S.A. Webster  
Presented at CMP, Ottawa, Ontario, January 18-23, 1993

Controlled Acid - Strong Acid Strip Process

R.C. Swider, S.A. Webster

U.S.A. Patent No.5,419,880 dated May 30, 1995.

Canada - Patent No.2,133,184 dated April 22, 1977.

Australia Patent No.681693 dated September 4, 1997.

Measuring Free Acid Concentration in Solution

R.C. Swider, S.A. Webster

U.S.A. - Patent No.5,798,268 dated August 25, 1998.

## DETAILS PROJECT MANAGEMENT - TECHNOLOGY DEVELOPMENT

<u>Metal</u>	<u>Project Name / Location</u>	<u>Client</u>	<u>Unit Operation</u>
U	Brannerite Beaverlodge,Sask. A-Zone, B-zone, D-zone Collins Bay B-Zone Eagle Point South & North Malawi Minatco, Sask.	Eldorado Nuclear Eldorado Resources Eldorado Resources Eldorado Resources Wright Engineering Consulting Engineers	Carbonate leaching Leaching, solvent extraction Ni recovery from raffinate Leaching, solvent extraction Leach, IX, SX, Pptn, effluent treat,enviro Leach, SX, Pptn, effluent treatment, Mo removal, environmental, mine water treat., pres. filtration
	Midwest Lake, Sask.	Midwest Joint Venture	Leach, SX, Pptn, effluent treatment, environmental tailings solidification
	Midwest Lake, Sask. Baker Lake NWT	Melis Engineering Urangesellschaft	Leach, SX, Pptn, efflu. treatment, IX for Mo removal Leach, SX, Pptn. effluent treatment environmental
	Minatco/Midwest Sask. Canada Strong Acid Strip Cabot Residue	Total Minatco/Midwest Richard C. Swider Recodyne/IUC	Leach, SX, Pptn, effluent treatment environmental Solvent extraction Solvent Extraction
Zr, Y, REO REO	Strange Lake	Greenland Acadia Min. Venture	Highwood Resources solvent extraction Leach, liquid/solid separation
Zr	Wimmera, Australia	Wimmera Ind. Min.	Leaching, calcining, autoclave
Zn	EAF Dust	Philip Environmental	Leaching, effluent treatment
Lu/Ce	LSO Recycle, TN, USA	CTI, Inc.	Digestion, solvent extraction, precipitation
La/Ce/Pr/Nd/Sm	Haiwei, China	Inter-Citic Envirotec	Dissolution, solvent extraction, precipitation

<b>Metal</b>	<b>Project Name / Location</b>	<b>Client</b>	<b>Unit Operation</b>
Zr, F	Zircaloy Etching	G.E. Canada,	Effluent Treatment
Zr	Cotter Corp., CO, USA	MRSI and CMS	calcination, water/acid leach, SX, precip
Zn, Pb, Cd		EAF Dust	Ivaco Leaching, effluent treatment
EAF Dust		Dofasco	Leaching, effluent treatment
EAF Dust		Fluor Daniel Wright	Solvent extraction
Zn,Mn		Yava, NS	Centaur Mining Solvent Extraction
In	Kidd Creek, Ontario	Kidd Creek Mines	Solvent Extraction
In	Mount Pleasant	Minerals Associate	Precipitation
Cu	Kidd Creek, Ontario	Kidd Creek Mines	Pressure filtration
Cu	Williams Creek, Yukon, Can	Silver Standard Mines	Leaching, solvent extraction
Cu, Au		DuPont Melis Engineering	E.I. DuPont Carbon adsorption, ion exchange Cyanide Leaching, acid leaching
Cu, Ag		DuPont, USA	E.I. DuPont de Nemours Leaching, ion exchange
Cu, Zn		Sanyati, Zimbabwe	Reunion Mining/Kilborn Leaching, SX
Cu	DuPont	E.I. DuPont	Solvent extraction
Cu	Santa Lucia, Cuba	Davy International	Leaching, SX, EW
Cu, Ni, Co		Dunka Road	A.D. Zunkel Cons/Nerco Leaching, SX
Copper Cake		Beta Metals/Cobatec	Leaching, precipitation
Co, Ni	Midwest Lake, Sask.	Midwest Joint Venture	Ppte, solvent extraction
Co, Ni	Cobalt, Ontario	Beta Metals/Cobatec	Precipitation, solvent extraction
Co, Ni	Key Lake, Sask.	Cameco Corporation	Leaching, Precipitation, SX, EW
Co, Ni	Kasese, Uganda	Canmine/Amec	Fe ppte, Zn SX, Cu ppte, Co SX
Co, Ni	North Cobalt, ON	Canmime	Fe ppte, Cu ppte, Zn SX, Co SX
Co,Cu,Zn,Mn		Boleo, Mexico	International Curator Ion exchange, solvent extraction
Ni	Plating Bath Sludge	Lasir Gold	Effluent treatment
Ag, Au		Nerco Delamar, USA	Delamar Silver Mines Cyanidation leaching
Au, Cu		Amine Derivatives	AKZO Chemical Bottle roll and column leaching
Au,Ag,Cu		Protium Metals	Dremco, USA Leaching, precipitation
As	Baghouse Dust	Industrial Minera, Mexico	Acid and caustic Leaching
As	Smealter Effluent India	Kilborn	Ferric arsenate precipitation
Ta	Reduction of Radioactivity	Tantalum Mining Corp.	Calcination, Leaching
Ta	Cabot Tantalum Residue	Recodyne/IUC, Utah	Solvent Extraction
Pd	Lac des Iles	North America	Solvent Extraction
		Palladium Company	
Pd	Gramco	Western Funding, Utah	Solvent Extraction
Sc	Cabot Residue	Recovery Dynamics, LLC	Solvent Extraction
Zr	Cotter/ CO, USA	MRSI / CMS	Calcination, Leach, Solvent Extraction, Precip

## **List of Project Experience**

**2009**

### **Royal Canadian Mint**

Provided a 1100 L fibreglass dish bottom tank with an mount for an air powered agitator.

### **BioMed International**

Designed and manufactured a laboratory solvent extraction pilot plant with pH controllers for a company in Kuwait.

### **Shepherd Widnes Ltd**

Designed and manufactured fifteen curve blade solvent extraction impellers for a cobalt solvent extraction plant in the UK.

### **Tshwane University of Technology**

Designed and manufactured a laboratory leaching pilot plant for a research program at the Faculty of Engineering at Tshwane University in South Africa.

### **Royal Canadian Mint**

Provided a 3 cubic foot filter press to the Royal Canadian Mint in Ottawa, Ontario, Canada.

### **Royal Canadian Mint**

Provided four fibreglass holding tanks each having 1000 L capacity for refining silver.

### **Votorantim Metais – Cajamarquilla S.A. - Peru**

Provided technical consulting service during commissioning of an indium solvent extraction plant.

### **Royal Canadian Mint**

Provided a second 3 cubic foot filter press to the Royal Canadian Mint in Ottawa, Ontario, Canada.

### **Areva Resources Canada**

Designed and manufactured a laboratory solvent extraction pilot plant with pH controllers for a test program at the McClean Lake mine site in northern Saskatchewan, Canada. The pilot plant was used to test various methods for uranium stripping.

### **Tanzania Gold**

Designed and manufactured a small scale plant for the recovery of gold from a placer deposit in Tanzania. The process included leaching gold with sodium cyanide followed by carbon adsorption and electrowinning.

### **Royal Canadian Mint**

Manufactured anode diaphragm bags for a gold electro-refining cell.

### **Shepherd Chemicals**

Designed and manufactured nine mixer-settlers for a cobalt nitrate solvent extraction plant.

### **Royal Canadian Mint**

Provided a 5 cubic foot filter press to the Royal Canadian Mint in Ottawa, Ontario, Canada.

### **Pacific Comex**

Designed and manufactured a gold electrowinning pilot plant for a mining project in Sonora, Mexico.

## **2008**

### **Votorantim Metais – Cajamarquilla S.A. / AMEC - Peru**

Designed and manufactured twelve mixer-setters for indium solvent extraction at a zinc refinery in Cajamarquilla, Peru.

### **Royal Canadian Mint – Ottawa**

Designed and manufactured two FRP dish bottom tanks for a gold hydrometallurgical process.

### **BioMed International**

Designed and manufactured a laboratory solvent extraction pilot plant with pH controllers for a research project in Kuwait.

### **Shepherd Color – USA**

Assisted with a laboratory test program on the development of a solvent extraction process for the recovery of cobalt from cobalt nitrate solution.

### **Shepherd Widnes Ltd. – UK**

Provided technical consulting on the design of the mixer box in a mixer-settler and designed and manufactured 15 SX curve blade impellers with drive units and motor mounts.

### **Tshwane University of Technology - South Africa**

Designed and manufactured a laboratory agitation leaching pilot plant. The pilot plant included four cascading leach vessels with mixers, feed tanks, pumps, and discharge tanks.

### **Royal Canadian Mint – Ottawa**

Provided a filter press for filtration of silver from a silver chloride solution.

### **KD Engineering**

Prepared engineering drawings for a copper solvent extraction and electrowinning pilot plant for a copper heap leaching project in Panama.

### **Royal Canadian Mint – Ottawa**

Provided four FRP holding tanks for silver refining.

### **Sary Kazna Mining Company LLP**

Provided on site consulting and supervision during the commissioning and plant start up of a copper dump leach, solvent extraction, and electrowinning project in Kounrad Kazakhstan.

**2007**

**Rio Tinto Minera Perú Limitada S.A.C.**

Designed and manufactured a modular solvent extraction and electrowinning pilot plant for a copper heap leaching project in Northern Peru.

**Norilsk Nikel Harjavalta Oy**

Designed and manufactured a laboratory solvent extraction pilot plant with ten stages of mixer-settlers for a research project in Finland.

**ZeaChem Inc.**

Designed and manufactured a laboratory solvent extraction pilot plant for the purification of acetic acid by a new proprietary technology. The laboratory plant featured sealed mixers and sealed settlers in order to use a solvent with a low flash point.

**Sary Kazna Mining Company LLP**

Designed and manufactured a large modular solvent extraction and electrowinning pilot plant for a copper dump leaching project in Kounrad (near Balqash) Kazakhstan. The plant produced 240 kg per day of copper with a design capacity of 100 L/min PLS.

**Gulf Chemical & Metallurgical Corporation**

Designed and manufactured a laboratory pilot plant for a uranium solvent extraction project.

**CV.Geodrill Indonesia**

We provided an electrowinning plant for a gold mining operation in Indonesia. The plant included an 800 ampere rectifier and an electrowinning cell with 15 cathode boxes. The plant can produce up to 140 kg per day of gold.

**PCS Phosphate- North Carolina**

Designed and manufactured a laboratory solvent extraction pilot plant featuring sealed mixers-settlers with jacketed settlers. The pilot plant included 18 mixer-settler stages with a jacketed organic vessel. The pilot plant was used to simulate their full scale solvent extraction column in their production plant for the extraction of impurities from phosphoric acid.

**Hellenic Copper Mines Limited**

Designed and manufactured a laboratory solvent extraction pilot for a copper mining company in Cyprus. The plant included 10 mixer-settler stages.

**Hamoon Chemi Co – Iran**

Assisted in a laboratory test programme aimed at the development of a new hydrometallurgical process to produce high purity cobalt sulphate crystals from a mixed cobalt oxide concentrate.

**Royal Canadian Mint – Ottawa**

Designed and manufactured a gold precipitation reactor.

**2006**

**MOL Hungarian Oil and Gas Plc**

Designed and manufactured a solvent extraction pilot plant with wetted parts of stainless steel and Teflon for the extraction of impurities from lube oils. The pilot plant was operated at high temperature, above the flash point of the solvent, under a nitrogen gas blanket in the mixers, settlers, and feed tanks.

**Management Services Inc**

Prepared a manual detailing a method for the recovery of gold from a gold concentrate. The method included oxidative chloride leaching followed by solvent extraction and reduction stripping.

**Arava Mines**

Designed and manufactured an electrowinning pilot plant for a laboratory test program aimed at the recovery of copper from an ore body in Israel.

**Siderúrgica Nacional Sidal S.A**

Provided technical consulting to an electrical arc furnace operation for the recovery of zinc and lead from EAF dust.

**Labzinc Industries**

Provided technical consulting on various hydrometallurgical processes on the recovery of zinc, copper, and nickel from various residues.

**Metals Finance**

Manufactured two coalescers for the recovery and entrained organic phase from a copper solvent extraction and electrowinning pilot plant project.

**MaSer Canada Inc.**

Provided technical consulting on the development of a hydrometallurgical process to recover zinc, copper, nickel, tin, silver, gold, palladium, and platinum from scrap computers.

**Minera Pampa de Cobre**

Designed and manufactured an electrowinning pilot plant for a copper project in Peru.

**2005**

**DERMET SA de CV**

Provided technical consulting on the implementation of a solvent extraction circuit, coupled to copper crystallization, for the production of copper sulfate from scrap copper metal.

**National Iranian Copper Industries Company**

Designed and manufactured a laboratory solvent extraction pilot plant with 10 stages of mixer-settlers.

**Iran Mineral Processing Research Center**

Designed and manufactured a portable and modular solvent extraction pilot plant that can be configured for any number of extraction, scrubbing, or stripping stages.

**Iran Mineral Processing Research Center**

Designed and manufactured a portable and modular electrowinning pilot plant that can be configured for either copper, cobalt, or nickel electrowinning.

**KD Bryansk Ltd / Moscow State Institute of Steel and Alloys**

Sold solvent extraction reagents to include: Escaid 110 diluent and 3,000 L of LIX extractant.

**KD Bryansk Ltd / Moscow State Institute of Steel and Alloys**

Sold electrowinning reagents to include: Galactasol 20H3C 41 and hollow polypropylene balls. We also provided copper hanger bars.

**KD Bryansk Ltd / Moscow State Institute of Steel and Alloys**

Sold pilot plant reagents to include: 2 drums of Polyox coagulant and 10 bags of bags of diatomaceous earth filter aid.

**Royal Canadian Mint**

Designed and manufactured a six agitation leaching plants for the extraction and purification of silver.

**Kasese Cobalt Company Limited**

Provided technical consulting on methods to minimize organic entrainment, crud formation, organic losses and consulted on methods of crud treatment.

**Isle Mining and Exploration**

Provided technical consulting on solvent extraction of gold from oxidative chloride Solution followed by direct reduction of gold from the organic phase.



**2004**

**Falconbridge Limited / Kidd Creek.**

Conducted solvent extraction tests to determine the extraction distribution curve of molybdenum by Alamine 336 from Indium plant SX feed.

**Falconbridge Limited / Kidd Creek.**

Provided solvent extraction coalescer media for the mixer settlers at Kidd Creek Indium solvent extraction plant.

**Southern Peru Copper Corporation.**

Designed and manufacture an electrowinning pilot plant for the leach / solvent extraction / electrowinning plant at the Toquepala copper mine in Tacna, Peru.

**Moscow State Institute of Steel and Alloys (Technological University)**

Provided mineral processing pilot plant equipment for the Udokan project in North eastern Russia. The equipment included Knelson concentrators, Falcon concentrators, Eriez magnetic separators, Bico bond ball mill, and F.W. Bell Gaussmeters,

**Moscow State Institute of Steel and Alloys (Technological University)**

Manufactured 10 anodes for a copper electrowinning pilot plant.

**Moscow State Institute of Steel and Alloys (Technological University)**

Designed and manufactured laboratory scale leaching, solvent extraction and electrowinning pilot plants for research programs at Moscow State Technical University.

**Erdenet Mining Corporation**

Designed and manufactured a copper solvent extraction and electrowinning pilot plant for a project in Mongolia. The pilot plant included 6 mixer settlers in the solvent extraction circuit and 4 cathodes in the electrowinning circuit. The plant was sized to produce 60 g of copper per hour.

**Royal Canadian Mint**

Designed and manufactured a small batch leaching plant for the extraction of gold, palladium, and platinum. The plant included the leach tank with agitator and feed and transfer pumps.

**SR&ED / SX Kinetics, Inc.**

Conducted a scientific research and experiment development program to evaluate flat blade impellers to curve blade impellers. The program determined that a curve blade SX impeller enhance the performance by providing higher pumping flow rates at lower impeller tip speeds. This gave less shear and in turn less entrainment. These new impellers are now provided on all of our laboratory solvent extraction pilot plants.

## **2003**

### **Heraeus Metal Processing, Inc.**

Designed and constructed a solvent extraction pilot plant for the extraction of precious metals. The plant included 6 mixer-settlers with variable speed mixer motors coupled to polypropylene SX impellers. The plant was completely assembled on a support frame and included the feed pumps.

### **Versitile Industries, Inc. / Battelle**

Designed and constructed a solvent extraction proto-type plant for the recovery of chromium from chrome plating shop waste waters. The plant was shipped to a US airforce base in Utah.

### **Moscow State Institute of Steel and Alloys (Technological University)**

Manufactured a bench scale solvent extraction and electrowinning pilot plant for the recovery of copper for an ore body in Russia. The plant was sized to produce 570 grams of copper cathode per day.

### **Moscow State Institute of Steel and Alloys (Technological University)**

Assembled 60 anodes for a large scale electrowinning pilot plant.

### **Moscow State Institute of Steel and Alloys (Technological University)**

Designed and manufactured a large scale copper solvent extraction pilot within 10 modular shipping frames. The pilot plant was sized to process 50 L/min of SX feed containing 5.6 g/L copper. The plant included the feed tanks, mixer-settlers, coalescer, organic tank, transfer tanks, and a crud treatment circuit.

### **North Group Inc.**

Sold 2000 kg of di-2-ethyl-hexyl phosphoric acid (DEPHA) to a Russian-Canadian Trading Company for shipment to Russia.

## **2002**

### **New Jersey Institute of Technology**

Designed and constructed a solvent extraction pilot plant for the extraction of proteins.

### **Amec / Canmine / MFC Bancorp Ltd.**

Conducted, as part of a team, a due diligence evaluation of a cobalt refinery in Kasese, Uganda. The cobalt refinery included the following unit operations: bio-leaching, ferric precipitation, zinc solvent extraction, copper precipitation, cobalt solvent extraction, cobalt electrowinning, and nickel precipitation.

### **Canmine Resources Corporation**

Designed and manufactured a laboratory scale solvent extraction pilot plant. The plant was manufactured from pyrex and included twelve stages. The unit was for the evaluation a new process for the removal of impurities from cobalt solutions.

### **Canmine Resources Corporation**

Provided on site technical consulting during plant commissioning and plant start up of a new cobalt refinery. The process involved autoclave leaching, impurity precipitation, cobalt solvent extraction, cobalt and nickel precipitation, and silver recovery by cyanidation and cementation. Prepared SX plant operations instructions and trained operators.

## **2001**

### **Mineral Recovery Specialists, Inc**

Provided technical consulting services for the implementation of a new hydrometallurgical process to recover zirconium at a uranium mill owned by Cotter Corporation in Colorado.

### **Pacific Ores Metals and Chemicals, Inc.**

Conducted a technical review of testwork on a tantalum and niobium project. The review included the results from a laboratory investigation on the leaching and tantalum/niobium solvent extraction.

### **Summo Minerals Corporation**

Prepare a basic review of current technical information on the Tarrazas project for the recovery of copper and zinc. The review included various flowsheet options to minimize or eliminated the need to neutralize acid prior to zinc solvent extraction. SX Kinetics provided a novel method to deplete copper prior to zinc SX and a method to remove and recover iron by solvent extraction.

### **Kress Enterprises, Inc.**

Designed and manufactured a solvent extraction plant to clean and stabilize gasoil that was produced from waste motor oil. The plant was shipped to Belgium.

## **2000**

### **Versitile Industries Inc. / Battelle**

Designed and fabricated a mobile solvent extraction pilot plant inside a 40' cargo container. The mobile SX plant was operated at various electro-plating sites for the demonstration of a new solvent extraction process to recover chromium from spent plating bath solutions. On site technical consulting was also provided during plant start-up.

### **CMS Enterprises**

Fabricated a turn-key solvent extraction pilot plant for zirconium. The plant included six mixer-settlers, feed and transfer tanks, structural support frames, containment trays, and all piping, valves, fittings, and process control. The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

### **Mineral Recovery Specialists, Inc**

Provided technical consulting services for the development of a hydrometallurgical process to recover zirconium from an ore in South America. The process included calcinations, leaching, solvent extraction, and precipitation. Supervised the start-up and operation of a solvent extraction pilot plant for the recovery of zirconium. Assisted in the engineering design of a full scale (750 gpm organic flow) zirconium solvent extraction plant.

### **CMS Enterprises**

Fabricated a turn-key solvent extraction demo (3 ½ time larger than the prior plant) plant for zirconium. The plant included six mixer-settlers, feed and transfer tanks, structural support frames, containment trays, and all piping, valves, fittings, and process control.

The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

### **CMS Enterprises**

Fabricated a turn-key water leaching demo plant. The plant included three cascading tanks, agitators, impellers, immersion heaters, structural support frame, and all piping, valves, fittings, and process control.

The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

### **CMS Enterprises**

Fabricated a turn-key CCD demo plant. The plant included four cascading thickener tanks, agitator drive units with stainless steel rakes, moyno under flow pumps, structural support frame, and all piping, valves, fittings, and process control.

The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

### **CMS Enterprises**

Fabricated a turn-key acid leaching demo plant. The plant included three cascading FRP tanks, agitators, impellers, immersion heaters, structural support frame, and all piping, valves, fittings, and process control.

The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

### **CMS Enterprises**

Fabricated a three turn-key precipitation circuits for a demo plant. The circuits included five cascading stainless steel tanks, agitators, impellers, immersion heaters, structural support frame, and all piping, valves, fittings, and process control.

The plant was fabricated in Canada and shipped the client's site in Colorado, USA.

## **1999**

### **Mineral Chemicals Inc.**

Participated in technical meetings to develop a conceptual process flowsheet for the recovery of zinc, copper, and indium from a calciner concentrate. The process involved selective leaching followed by solvent extraction of copper and indium.

### **Inter-Citic Environtec, Inc.**

Participated in a technical review at the Jiangsu Haiwei Rare Earth Processing Facility, in China, for the expansion of plant capacity from 1,400 tonne per year to 2,500 tonne per year and the up-grade of product quality to 99.9 % La<sub>2</sub>O<sub>3</sub>, 99.95 % CeO<sub>2</sub>, 99.5 % Pr<sub>6</sub>O<sub>11</sub>, and 99.9 % Nd<sub>2</sub>O<sub>3</sub>. The expanded / up-graded process included six solvent extraction circuits having a total of 395 mixer-settlers.

### **CTI, Inc.**

Prepared a detailed proposal for engineering, technical design, procurement, and construction of a modular hydrometallurgical plant for the recovery of lutetium from scrap lutetium-silica-oxide (LSO) crystal detectors. The plant has the capacity to treat 338 kg of LSO per day.

### **CIMTEC, S.A.**

Prepared a detailed proposal for the supply of an SX-EW plant for the recovery of cobalt mixed nickel-cobalt sulphides. Provided technical assistance for the economic viability of producing one tonne per day of 99.9 % cobalt metal from the mixed sulphide by-product.

## **1998**

### **Recovery Dynamics, LLC**

Assisted in the development of solvent extraction technologies for the recovery of uranium, tantalum, and scandium from a tantalum digestion residue. The process utilized two solvent extraction circuits: The primary circuit used Primine JM-T extractant for the recovery tantalum, and the secondary used a mixture of DEHPA and Cyanex 923 for the recovery of uranium and scandium. A novel method for scrubbing and stripping was developed.

### **Recovery Dynamics, LLC / International Uranium Corporation**

Provided on site technical assistance (over a period of 11 months) for the conversion of uranium and vanadium solvent extraction circuits, at the White Mesa uranium mill, to SX circuits for the recovery of uranium, tantalum, and scandium.

### **Fansteel, Inc.**

Provided three turn-key solvent extraction plants for the recovery of uranium, tantalum, and scandium at their site in Muskogee, Oklahoma. The plants were manufactured in Canada, and shipped to Oklahoma in October, 1998.

### **University of Tennessee**

Supplied a complete 15 stage solvent extraction pilot plant. The plant included mixer-settlers manufactured from pyrex glass with PVC impellers and variable speed agitators. The pilot plant was manufactured in Canada, and shipped to Tennessee in May, 1998.

### **CTI, Inc.**

Consulted on solvent extraction technology for the recovery of lutetium from lutetium crystal reject material. Prepared P&ID's, mass balance calculations, and plant layout for a complete hydrometallurgical process which included grinding, digestion, solvent extraction, precipitation, calcination, and effluent treatment.

## **1997**

### **Cobatec Limited**

Provided technical assistance, in association with Richard C. Swider Consulting Engineers Limited, for a plant audit at Cobatec Limited cobalt production facility in northern Ontario.

### **Geominera, S.A.**

Prepared a business plan for the creation of a new corporation that would provide a facility for contract research and development.

### **Commerical Caribbean Nickel, S.A. / Cobatec Limited**

Introduced Cobatec to business and technical representatives of CCN, for obtaining a contract to supply Cobatec's plant in Canada with a mixed nickel/cobalt concentrate.

### **Cobatec Limited**

Prepared an operational set of guidelines for the operation of Cobatec's SX plant, and provided training for their operators.

### **Centaur Mining Exploration Limited**

Consulted on Zn, Mn, and Pb solvent extraction by Cyanex 302, Cyanex 272, DEHPA, and DEHPTA extractants. Calculated mixer-settler requirements for their process.

### **Gramco Inc.**

Consulted on leaching of gold and silver from scrap printed circuit boards, and the effect of the lixiviant on the subsequent solvent extraction steps.

### **Recovery Dynamics, LLC**

Provided on site assistance, for the development of new solvent extraction technology, for the recovery of scandium, tantalum, and uranium from a tantalum residue.

## **1996**

### **Western Holdings Inc. (Gramco)**

Assisted in the implementation of a palladium solvent extraction circuit at a precious metals recovery plant in Woodcross, Utah. Negotiated, on behalf of the client, with petro-chemical manufacturers, for the production and sale of 1.5 tonnes of di-n-octyl sulphide.

### **Dremco Inc.**

Provided a hydrometallurgical flowsheet for the recovery of gold, silver, and copper from scrap jewelry. Located suppliers of components for a scale plant to recover 1 kg of gold per day.

### **Centaur Mining Exploration Limited**

Provided technical assistance on a solvent extraction process for the recovery of zinc and manganese from an acetate leach solution containing a high concentration of calcium. The ore body, known as "Yava" is located near Sydney, NS.

### **Minerals Associates**

Developed 4 conceptual processes for the recovery of indium, copper, and zinc from the Mount Pleasant ore body.

## **1995**

### **EGO Resources / Cobatec**

Provided on site technical assistance during construction and start up of a cobalt solvent extraction plant.

### **Kilborn Inc.**

Conducted an effluent treatment program for the removal of arsenic and other heavy metals from a copper smelter effluent in India.

### **International Curator**

Developed, as part of a team, a process for the recovery of cobalt, copper and zinc from an ore body in Boleo, Mexico. The leach solution, had twice the salt concentration of sea water and contained a high concentration of manganese. The test program evaluated various options using ion exchange and solvent extraction technologies.

### **Richard C. Swider Consulting Engineers Limited**

Studied the effect of chloride ion concentration during the crystallization of ammonium sulphate at a typical uranium plant. Developed a method for the removal of chloride ions during uranium solvent extraction.

### **Cameco Corporation**

Designed, procured and constructed a pilot plant inside 4 shipping containers for the recovery of cobalt and nickel from Key Lake uranium tailings. The plant included autoclave leaching, atmospheric leaching, 5 stages of CCD washing, selective precipitation, pressure filtration, 3 separate solvent extraction circuits, and 2 electrowinning circuits for cobalt and nickel. Supervised plant set up, start up and 4 months operation.

## **1994**

### **EGO Resources / Cobatec**

Developed a conceptual process for the recovery of cobalt, copper, zinc, and cadmium from zinc refinery waste material known as "copper cake". The process included selective zinc leaching, oxidative vat leaching, copper SX / EW, cadmium precipitation, ferric arsenate precipitation, and cobalt solvent extraction.

### **Westminer Canada Limited**

Conducted bottle roll leach tests using sulphuric acid at pH 1.8, for the evaluation of El Indio copper oxide ore body in Chile.

### **Davy International**

Designed, procured, and constructed a copper SX / EW pilot plant, including agitation leaching, 4 stages of CCD washing, and three 85 tonne heap leach cribs. Supervised plant set up and start up in Santa Lucia, Cuba. Trained Cuban operators.

### **Falconbridge Limited / Kidd Creek Division**

Provided technical consulting services on phase disengagement and loading capacity problems in the cottrell dust indium SX plant.

### **North American Palladium Company**

Developed a solvent extraction process for the recovery of gold, palladium, and platinum from an aqua regia leach solution. Di-octyl-sulphide and ZnX 50 extractants were evaluated for palladium recovery.

**1993**

### **AKZO Chemicals**

Evaluated various amine derivatives for reducing cyanide consumption during leaching of gold ores containing copper.

### **E.I. DuPont**

Assisted in the development of a new process to simultaneously recover gold, copper and cyanide from high cyanide consuming ores.

### **El Condor Resources Ltd.**

Conducted bottle roll leach tests for copper with sulphuric acid followed by cyanidation leaching on the washed residue for gold.

### **Lac des Iles**

Conducted solvent extraction tests for the extraction of palladium from chloride solutions. The test program evaluated Acorga CLX-50, Cyanex 471X and, di-n-octyl sulphide extractants.

### **Total Minatco (Richard C. Swider)**

Studied the chemical stability of siloxirane coating under various process conditions.

### **Beta Metals/Cobatec Ltd.**

Developed a solution purification/solvent extraction process for the recovery of cobalt and nickel from arsenic containing ores. The process included precipitation for removal of impurities, followed by cobalt solvent extraction. Cobalt electrowinning and nickel precipitation were evaluated as methods for product recovery.

### **Cameco Corporation**

Supervised a test program for the recovery of nickel and cobalt from uranium tailings. The program included impurity precipitation tests, the development of a solvent extraction circuit, followed by electrowinning tests.

### **Western Copper Holdings Ltd.**

Designed, constructed, and supervised the start-up and operation of a solvent extraction/electrowinning pilot plant for the recovery of copper from a large scale heap leaching test. The test was conducted on site, near Carmacks, Yukon, Canada.

### **Richard C. Swider/Lakefield Research**

Co-invented a solvent extraction process for the recovery of sulphuric acid. A patent application was filed in October 1993.



### **Fluor Daniel Wright**

Conducted a test program for the development of a solvent extraction process to recover zinc from EAF dust. The extraction of zinc chloride by Acorga's ZNX 50 was evaluated.

**1992**

### **Total Minatco/Midwest Joint Venture Integrated Project**

Confirmed Minatco's integrated flowsheet for processing a blend of Minatco and Midwest ore. The test program included two stage leaching, a large scale batch leach, a bulk solvent extraction test and tailings effluent treatment.

### **Tantalum Mining Corporation**

Invented a process to reduce radioactivity from tantalum concentrates. The process included silica calcination, hydrochloric acid leaching, and acid regeneration.

### **Kilborn Inc./Reunion Mining (Zimbabwe) Limited**

Developed a flowsheet for the recovery of copper and zinc from Sanyati ore. The flowsheet incorporated heap leaching, copper solvent extraction with Acorga M5640 and zinc solvent extraction with D2EHPA. A novel process was developed to remove ferric iron.

### **Midwest Joint Ventures**

Conceived and developed a process to recover cobalt and nickel from uranium raffinate. The process included two stage precipitation for removal of impurities followed by cobalt-nickel precipitation. Solvent extraction for the separation of cobalt from nickel was evaluated. The process was presented at the CMP conference in January 1993.

### **Silver Standard Resources Inc.**

Conducted locked cycle bottle roll leach tests, incorporating solvent extraction, on Williams Creek copper oxide ore. The test simulated a heap leaching-solvent extraction process.

### **A.D. Zunkel Consulting/Nerco Minerals Company**

Directed solvent extraction testwork to recover copper, cobalt and nickel from a ferric chloride leach solution. The process included copper solvent extraction with Acorga CLX 50, ferric iron solvent extraction with TOPO, and cobalt solvent extraction with TIOA.

### **E.I. DuPont**

Constructed and operated an ion exchange stripper column to generate engineering design data for the elution of zinc cyanide from ion exchange resin.

### **E.I. DuPont**

Investigated the effect of sodium cyanide and calcium cyanide lixivants on the extraction efficiency of copper and gold from various ores.

**1991**

**Consulting Engineers Limited/Total Minatco Limited**

Supervised a test program for the development of a flowsheet to recover uranium from Minatco's Sue A and Sue B ores. The flowsheet included atmospheric H<sub>2</sub>SO<sub>4</sub>/NaClO<sub>3</sub> leaching, solvent extraction, hydrogen peroxide precipitation, effluent treatment, and environmental studies.

**E.I. DuPont/Delamar Silver Mine**

Optimized leaching conditions to reduce sodium cyanide consumption from 1.5 kg/t NaCN to less than 0.3 kg/t NaCN. Silver and gold leaching efficiency were not compromised.

**Wimmera Industrial Minerals**

Assisted in the development of a process to reduce the radioactivity of zircon concentrates. The process included lime calcination, hydrochloric acid leaching, and spray evaporation. The process was patented in 1992.

**General Electric Canada Limited**

Conceived and developed a process to treat spent zircaloy etching solutions for fluoride and zirconium removal.

**Ivaco Rolling Mills Limited**

Conducted leaching and sulphate roasting tests on electric arc furnace (EAF) dust samples to examine various processing options for the recovery of zinc.

**Dofasco Limited**

Conducted leaching tests on an EAF dust sample using various lixiviants.

**Philip Environmental**

Conducted leaching tests on an iron flue dust sample.

**Industrial Minera Mexico**

Conducted caustic, acid, and water leaching tests on an arsenic baghouse dust sample.

**Lakefield Research**

Conceptualized a process for the recovery of zinc, cadmium, and lead from electric arc furnace dust. The conceptual flowsheet included two stage sulphuric acid leaching, zinc solvent extraction using D2EHPA, cadmium and lead cementation.

**Consulting Engineers Ltd./Urangesellschaft Canada Ltd.**

Supervised a test program for the confirmation of a flowsheet to recover uranium from Sissons-Schultz ore. The program included leaching, thickening, solvent extraction, uranium precipitation, effluent treatment, and environmental testing.

**1990**

**Highwood Resources Inc./Strathcona Mineral Services**

Directed a solvent extraction test program for the development of a process to recover zirconium from sulphate leach solutions. The process included Alamine 336 extraction, dilute acid scrubbing, and stripping by strong sulphuric acid. A novel mechanism was discovered to minimize impurity co-extraction.

**Melis Engineering/PNC Exploration**

Supervised a test program for the development of a flowsheet to recover uranium from Midwest ore. Carbon adsorption was evaluated for the recovery of molybdenum.

**Melis Engineering/Midwest Joint Ventures**

Supervised and operated a solvent extraction pilot plant to evaluate various scrub solutions and stripping processes. Hydrogen peroxide precipitation was evaluated on pilot plant strip liquors. Effluent treatment and tailings solidification tests were conducted on process stream solutions and leach residues.

**Kilborn Inc./Acadia Limited**

Conducted leaching, settling, and filtration tests on Strange Lake ore and concentrates for yttrium and zirconium recovery.

**Kidd Creek/Falconbridge Limited**

Conducted pressure filtration tests on copper concentrates.

**1989**

**Wright Engineering (Fluor Daniel Wright)**

Supervised a test program to develop a flowsheet for the recovery of uranium from Malawi ore. Unit processes included grinding, leaching, thickening, ion exchange, solvent extraction, uranium precipitation, effluent treatment, and environmental testing.