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THE GEOCHEMICAL LABORATORY INDUSTRY 1980 TO 2025: WHERE WE STARTED AND WHERE WE ARE HEADED

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The Commercial Geochem Laboratory Industry

- Commercial Geochem laboratories are unique in the testing industry:
  - They process a mixture of mineral exploration, production and final mineral commodity samples on a contractual basis;
  - They analyze samples and report data from the PPT to high % level often on the same sample;
  - These laboratories process the complete range of exploration samples from fresh water, brines, vegetation, soils, sediments, rocks and drill cores;
  - The sample preparation process required to prepare the samples for analysis employs physical processes that are energy intensive, yet produce final samples free of carryover contamination;
  - The laboratories usually do not know the concentration ranges of the analytes they are testing; and
  - These laboratories have methods that provide high quality for 70% of the periodic table from crustal abundance to final processed product concentration ranges.

SGS's Sample Preparation Laboratory in Tarkwa Ghana

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The Commercial Geochem Laboratory Industry

- The sample types and data end use require a complete range of sample digestion techniques from:
  - Aqua Regia (reverse and conventional);
  - 4 acid, near total digestions (HCl, HNO3, HClO4 and HF);
  - Alkali fusions (borate, NaOH, Peroxide); and
  - Specialized digestions (Mobile Metal Ion, Hydroxylamine, Acetic Acid, etc.
- Most Geochemical laboratories employ a range of final measurement methods including:
  - Classical chemistry, including gravimetric, titrimetric, colorimetric and specific ion methods;
  - Flame AAS, ICPOES and ICPMS methods;
  - Fire Assay;
  - XRF and XRD;
  - Instrumental Neutron Activation (INAA); and
  - Gamma Activation Analysis (GAA).

SGS's XRF bench in Lakefield

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The Commercial Geochem Laboratory Industry

- The global commercial Geochem laboratory industry is dominated by four large publicly traded Testing, Inspection and Consulting companies (TIC), ALS (Australia), BV (France), Intertek (UK) and SGS (Swiss).
- The companies are multidisciplinary as they also have large Environmental, Oil & Gas, Consumer Goods, Industrial, Agricultural and Food testing businesses.
- Combined their Geochem laboratories process on average somewhere between 50 and 60 million geological samples per annum from operations in >35 countries.

ALS's North Vancouver Minerals Laboratory Campus, estimated at 40,000 m^2

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The Commercial Geochem Laboratory Industry

- The three largest facilities are ALS' North Vancouver laboratory (8.0-10.0 million samples per annum), Intertek's Perth laboratory (7.0-9.0 million samples per annum) and BV's Perth laboratory (6.0-8.0 million samples per annum).
- These central, hub laboratories are massive:
  - Intertek's Perth hub laboratory is 20,000 m^2 in size and employs over 500 personnel working 24/7/365.

Intertek's Triple Quad ICPMS bench in Perth

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The Commercial Geochem Laboratory Industry: Early Years

- The 1960's and 1970's saw the emergence of mining company owned inhouse laboratories like Western Mining (Aus), Cominco, INCO and Lakefield Research (Falconbridge owned, Canada), AARL, Billiton, Gold Fields (RSA) and Kennecott Expl. Services (USA).
- During this same time frame governments around the globe were building up large survey laboratories in the USA (USGS), Canada (GSC, OGS, SRC, BRGM (France).
- In the former Soviet Union, the central mining authority was developing a tightly controlled and prescribed laboratory network across its vast geographic expanse (Kazakhstan, Russia, Uzbekistan, etc.).
- The mining company and government survey laboratories of the 1960's and 1970's trained an entire generation of chemists that left to start or work in the early commercial laboratory industry.

Irgiredmet Laboratory Facility in Irkutsk Russia

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The Commercial Geochem Laboratory Industry: 1960 to early 1980's

- A significant number of family-owned commercial laboratories were formed during this time frame in:
  - Australia (Aus Lab Services, Analabs, Geochemical and Mineralogical Laboratories, GenAlysis);
  - Canada (Actlabs, ACME, Assayers, Barringer, Bell&White, Bondar-Clegg, Chemex, Swastika, XRAL); and
  - USA (Cone Geochemical)
- The owners/chief chemists for many of these early commercial laboratories had been trained in corporate mining or survey laboratories and were either released due to downsizing or grew tired of big corporate or government life.

BONDAR-CLEGG

BARRINGER RESEARCH LIMITED
TORONTO, CANADA

GENALYSIS
LABORATORY SE

CONE
GEOCHEMICAL INC.
810 Quail Street, Suite 1
Lakewood, Colorado 80215
(303) 232-8371

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The Commercial Geochem Laboratory Industry: 1970 to early 1980's

- These companies took on the personalities of their owners and were fiercely independent and very entrepreneurial.
- Founders like:
  - Tony Barringer (Barringer);
  - Bill Bondar (BCC);
  - Ted Brooker (XRAL);
  - Bruce Brown (Chemex);
  - the Campbell Family (ALS);
  - Murray Chapman (Analabs);
  - Steve Cone (Cone);
  - Dean Toye (ACME); and
  - Terry Wheeler (GenAlysis)

  established reputations as tough, no-nonsense businessmen that were able to navigate a client base and business turnover that was constantly expanding and contracting as exploration dollars waxed and waned.

Tony Barringer

Bill Bondar

Steve Cone

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The Commercial Geochem Laboratory Industry: 1970 to early 1980's

- Many of these businesses also branched out beyond their core mining-based laboratory business to create bigger entities:
  - Barringer branched into geophysical equipment, providing on the ground geophysical surveys as well as creating novel geochemical sampling and testing approaches like Surtrace a helicopter supported "sniffer" technology and soil gas testing;
  - BCC started an instrument division designing and manufacturing energy dispersive onstream analyzers, but the business foundered when Outokumpu entered the market and bundled XRF analyzers with their flotation and grinding equipment;

Barringer Surtrace System in the field

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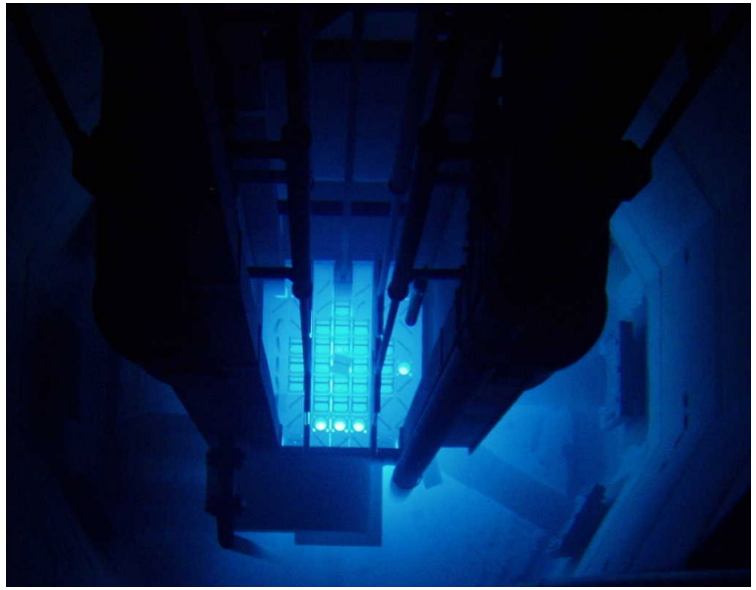
The Commercial Geochem Laboratory Industry: 1970 to early 1980's

- Chemex started and then spun off an environmental laboratory business;
- ALS started a successful environmental and oil testing business;
- XRAL pioneered the use of Instrumental Neutron Activation Analysis (INAA) for mining and non-mining applications;

- Many of the side ventures failed and in the case of BCC weakened the core business as management time and expansion capital were funneled towards the failing side venture.

- Barringer divested its laboratory business and focused its efforts on the geophysical and "sensing" equipment business.
  - Barringer designed and manufactured some of the first XRF based airport baggage scanners.



Snot of the core of a Slow Poke type research Nuclear Reactor commonly used for INAA work

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The Commercial Geochem Laboratory Industry: Late 1980's to mid-1990's

- The mid-1980's to mid-1990's saw a decade of rapid domestic and international expansion led by ALS, Analabs, Bondar-Clegg and Chemex.
- ALS's expansion was notable as they were able to tap into significant funds from the original Campbell Brothers listing on the Sydney Stock Exchange. ALS quickly became the global leader in geochemical laboratory services and further expanded their environmental and oil testing businesses.
- The growing industry also caught the attention of the traditional European based inspection companies when SGS purchased XRAL in 1988 and Inchcape/Intertek purchased BCC and Analabs in 1988/89.
- The entry of the large European inspection houses marked the start of a major change in the industry as smaller and mid-sized firms were consolidated to create large, globally focused networks.

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The Commercial Geochem Laboratory Industry: Late 1990's to 2010

- The global exploration industry ran into significant funding difficulties in the mid-1990's that lasted well into the 2000's.
- This period also saw investor confidence further challenged by several notable mining scams, the worst being BreX in 1998.
- The unsettled exploration funding situation created serious financial hardship for those laboratory groups that had expanded the furthest nationally and globally
  - Inchcape's view of the business soured, and they spun their non-mining laboratory division off as Intertek, sold BCC to its managers (Bill Sherwood, George Cartwright and others) and Analabs to the John Thompson led Scientific Services Limited.

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The Commercial Geochem Laboratory Industry: Late 1990's to 2010

- The Bre-X scam was also a defining moment for the Geochem laboratory industry as it:
  - Catalyzed government involvement in the regulation and control of mining data release to stock markets (NI-43101, JORC, etc.,);
  - Created an entirely new business as companies now needed QP's to audit and sign-off on laboratories and laboratory data;
  - Forced the global Geochem business to rapidly adopt ISO/IEC 17025 accreditation to document and prove "competence and fitness for testing" and to address auditor scrutiny;
  - The knock-on effect of all of this was the creation of comprehensive and formal quality control systems in the industry that moved the sector on par with the environmental, food and medical testing industries.

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The Commercial Geochem Laboratory Industry: Late 1990's to 2010

- However, this period also created significant buying opportunities for companies like ALS, BV, Intertek and SGS that sought to quickly grow their mining focused testing businesses.
- The global Geochem laboratory business was quickly consolidated and the purchase price multiples increased rapidly, peaking with the purchase of ACME (Canada) and Ultratrace (Australia) by BV in 2008.

SUPPLIERS NEWS ROUNDUP — Aussies buy assayer Chemex

POSTED BY: NORTHERN MINER STAFF OCTOBER 11, 1999

An Australian firm has bought Canadian minerals assayer Chemex Laboratory Group in a deal worth at least $8 million. Australian Laboratory Services (ALS), owned by Campbell Brothers, will add Vancouver-based Chemex and its U.S., Mexican and Peruvian labs to its stable of offices in Argentina, Chile and Laos. Chemex will be merged with ALS to become ALS Chemex.

Paris, May 2, 2008 –
Bureau Veritas has signed a definitive agreement to acquire a ll the shares of Amdel Holdings Pty Limited, an Australian lea der in minerals testing. The sale agreement is unconditional a nd is expected to be completed by May 7, 2008.

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The Commercial Geochem Laboratory Industry: Late 1990's to 2010

- This intense period of consolidation changed the face of the industry, creating large multi-national corporatized testing entities that had the financial muscle to invest in the latest analysis equipment platforms, LIMS, robotics and comprehensive QA/QC programs.
- The larger entities also provided a solid source of funding and operational acumen needed to respond to ISO/IEC accreditation and the increased government and client scrutiny of the sector in response to the mining scandals that occurred in the 90's.

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The Commercial Geochem Laboratory Industry: Late 1990's to 2010

- The larger networks were also well placed to take advantage of the outsourcing of mining and production laboratories as mining companies further consolidated and lost their laboratory technical and management expertise.
  - SGS and BV both leveraged their significant global networks to provide the local management, financial and operational support needed to operate laboratories in very remote and often hostile locations;
  - Other groups like Intertek stayed closer to their power centers and built modest onsite laboratory networks in Australia; and
  - SGS rapidly exploited its global footprint and rapidly became the largest outsourced mine laboratory operator in the business, growing from a modest 10 mine site labs in 2000 to >60 mine site laboratories in >20 countries in 2010.

SGS's Hope Bay Onsite Laboratory, Nunavut, -55 oC

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The Commercial Geochem Laboratory Industry: 2010 to 2020

- The decade 2010-2020 saw the maturation of the Geochem laboratory industry coupled with the emergence of intense competitive and operational complexing forces:
  - The major Testing, Inspection and Consulting companies had expanded and saturated every mining country globally sparking price wars to gain or hold on to market share;
  - Corporate profits came under pressure as sample volumes became harder to sustain, the price per sample stagnated or reduced, and HR and supply costs increased with inflation;
  - The commercial laboratory industry also increasingly struggled to attract young talent as the world's youth viewed laboratory jobs as non-desirable or second tier compared to better paying IT and technology careers.

SGS's Balkhash Laboratory, Kazakhstan

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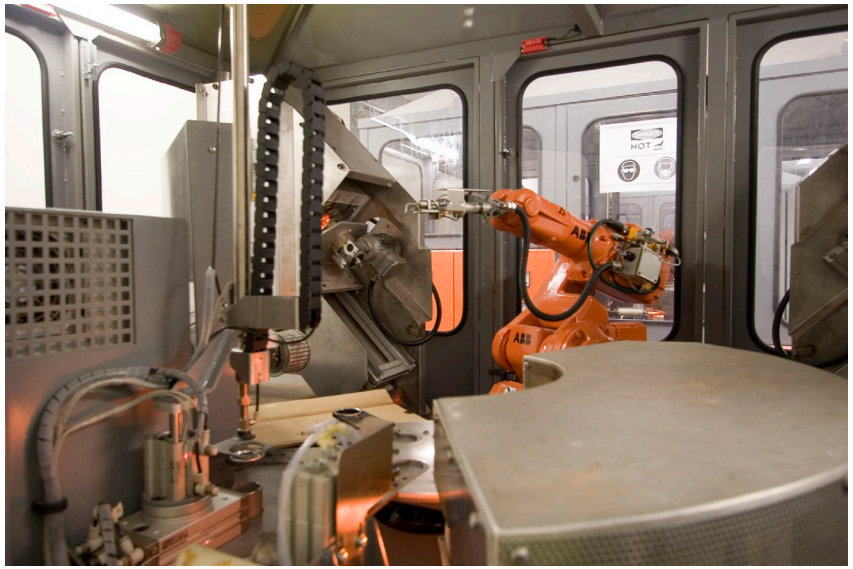
The Commercial Geochem Laboratory Industry: 2010 to 2020

- Laboratories responded to the price stagnation and HR issues by moving rapidly to automate the more labor-intensive aspects of their testing platforms.
- Unfortunately, the “whole process” automation efforts attempted in physical sample preparation and sample weighing, digesting, and fusing largely failed in the commercial sector:
  - All automation providers struggled with cross sample contamination issues and system up-time; and
  - Every system seemed to be a new engineering project so that design and capital costs never moderated.



SGS’s Automated Borate Fusion System, Perth

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The Commercial Geochem Laboratory Industry: 2010 to 2020

- Whole process automation has been successful in the iron ore and mineral sands commercial and production mine site laboratory sector (using borate fusion XRF platforms).
- Modest success has occurred in the gold and PGM production sector:
  - Only in operations where carryover contamination did not impede operational decisions; and
  - In operations large enough to carry expensive mechanical engineering support staff to keep the units running

FLS/IMP/Hertzog iron ore robotic system, FMG Christmas Creek Iron Mine

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The Commercial Geochem Laboratory Industry: 2010 to 2020

- Clients grew increasingly tired of slow data turnaround and a perceived lack of service to their projects.
- Their response was to start funding and promoting disruptive mobile field-based testing systems like:
  - Portable XRF;
  - XRF core scanners; and
  - Laser Induced Break Down Spectroscopy, etc.
- The effect of this field-based technology was to slowly and significantly reduce the number of samples per project that were being sent to commercial laboratories by 2020, putting even more pressure on per sample revenue.

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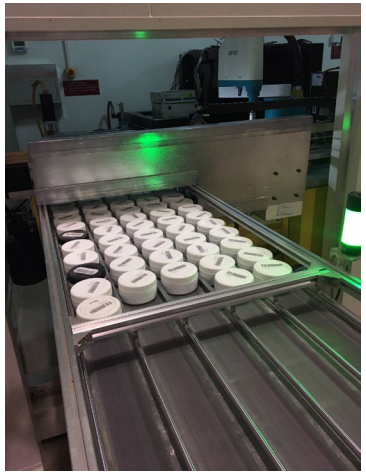
The Commercial Geochem Laboratory Industry: 2020 to now

- The 2020's have seen the rapid rise of disruptive technologies like Gamma Activation Analysis (GAA) and new and improved Portable XRF platforms.
  - Chrysos GAA went from 0% market share in 2020 to an estimated global market share approaching 45% in 2025 (by sample processing volume and excluding Russia)
- These new analytical systems and approaches have been driven by advances made in:
  - Signal detection systems;
  - Signal processing and pattern fitting software; and
  - The continued need by clients for faster turnaround and larger samples sizes for gold-based projects.



Chrysos System

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The Commercial Geochem Laboratory Industry: 2020 to now

- The pace of change in the geochemical laboratory industry continues to increase with the introduction of new and powerful disruptive technologies like:
  - The ColdBlock digestion system;
  - Improved field based XRF core scanning and core analysis systems;
  - Ultrafine powder direct injection Laser/MS analysis systems;
  - Continued improvement in tube-based Energy Dispersive XRF systems (Bruker, PanAlytical and others); and
  - Increasing pressure from regulators, shareholders, clients and staff to improve the work environments in traditional Geochem laboratories, by reducing worker exposure to silica dust, heat, lead, HF and HClO4 acids and other chemical reagents.

ColdBlock Pro Series CBL Large Sample Digestion System

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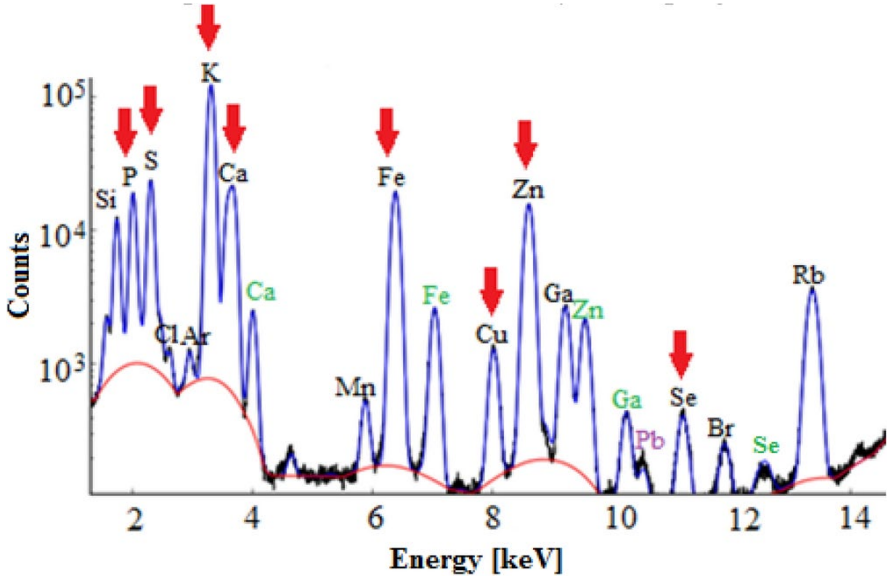
The Commercial Geochem Laboratory Industry: 2020 to now

- The next massive change/disruptive technology will be Artificial Intelligence.
- AI could have two impacts:
  - Clients will likely use the advanced and improved predictive powers it brings to data sets to yet again reduce the number of samples they need to send to laboratories; and
  - Laboratories will need to find a way to use AI to improve:
    - Sample throughput by predictive tail correction, i.e., rapid sample introduction and mathematical correction of carryover signal and other ways of shortening/increasing the speed of the analysis process;
    - Reduction in senior quality staff by using AI inspection of data with a subsequent improvement in the time to peruse, approve and release final data reports; and
    - Predictive analysis for equipment maintenance, just in time supply ordering; improved laboratory process scheduling, etc.



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The Commercial Geochem Laboratory Industry: 2020 to now

- The new disruptive technologies have continued the trend of reducing the samples sent to “bricks and mortar” based Geochemical laboratories and in the case of GAA have replaced one of the highest margin laboratory tests, Fire Assay.

- The net effect is that profit margins in the sector continue to decline and have led to ….

Testing giants Bureau Veritas and SGS in merger talks

By Reuters

January 15, 202510:40 AM EST Updated 23 days ago

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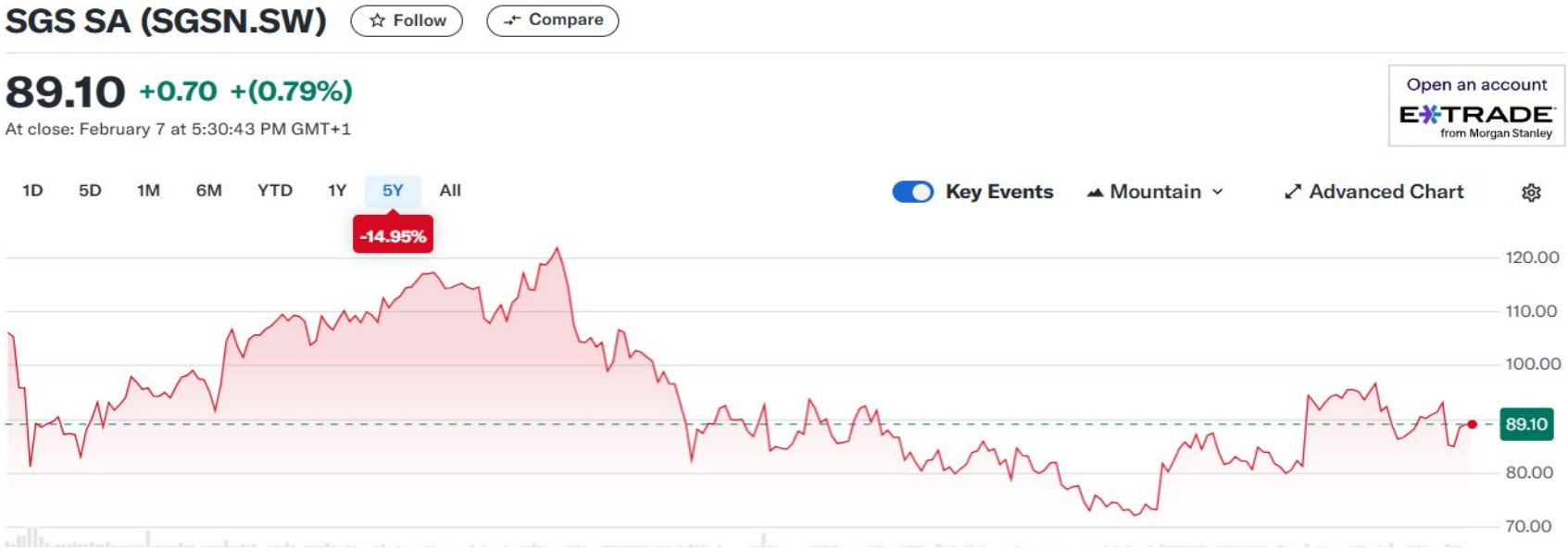
The Commercial Geochem Laboratory Industry: 2020 to now

- The SGS/BV merger appears to have fallen through for the time being.
- But it is a strong signal that the shareholders of the major TIC companies are not happy about financial returns and that there will be continued and building pressure for a major consolidation in the sector to occur soon.



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The Commercial Geochem Laboratory Industry: Future

- The geochemical laboratory industry is at a significant inflection point in its history.
- The way forward is very much governed by its ability to attract, develop, and retain skilled staff members and its ability to quickly embrace and commercialize new, disruptive technology, especially AI or AI influenced technologies/testing approaches.
- Any group that fails to be open to new approaches, technologies and AI won't survive.