

Developing Interest in Complex Systems: It's Where the Wicked Problems Live

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You may be curious as to how and why people get interested in Systems Thinking and its use in understanding the world in which we live. Working with Complex Systems thinking involves a holistic understanding of the interconnections within systems, the ability to analyse their dynamics, and a willingness to embrace uncertainty to tackle wicked problems and foster innovation.

But I am already diving too deep. My own interest in holistic thinking started over 30 years ago when I became a project generation geologist for Western Mining Corporation in Australia. By the 1980's, for a project to be accepted into the exploration portfolio, it had to be supported by a holistic integration of likely geological processes with empirical observations and regional data.

As with successful study of other complex systems, this holistic modelling process involved an interdisciplinary approach, drawing on the skills and wisdom of geophysicists, geochemists and other specialists. This collaborative process required trust, candour and support between peers and management, augmented by mentoring from internal experts.

This approach pushed targeting beyond the simple cookie cutter approach of looking directly for features seen in other deposits, towards an out-of-the-box perspective of what could be and most importantly where it could be. That said, it was still considered fundamental to start with building a list and mental model of mappable features at each type deposit. Both large and small deposits were studied in an attempt to determine what features, geometries could be used to differentiate between targets that could be giants from those that might be small or low grade and not be economically mineable.

Western Mining's exploration division had a very strong culture that made you feel like family. This encouraged people to take risks and try different approaches. We always tested a range of targets before leaving a project. Management understood it takes several years in a region to begin to get to grips with the limits and opportunities. Often where you end up is some distance from where you start as you learn from your failures. Key here is to fail fast and learn quickly. You learn nothing by being timid. Fortune favours the brave.

After I left Western Mining in 2001, I worked for a number of junior

companies during the industry downturn before the China led super-cycle took off, and continued even through the Global Financial Crisis. In 2011 I read an interesting, perhaps seminal article in Economic Geology Newsletter by a former peer and technical manager, Dr Jon Hronsky. Jon's article described how orogenic gold hydrothermal deposit systems could be the result of self-organised complex system (SOCS), whereby the fluid self-organises to overcome a local barrier or trap, resulting in a cascade of energy and fluid release that would result in deposition of metals.

I was fascinated by the new terminology, and the possibility that mineral systems could have goals, overcome barriers to fluid movement to reach the goal of deposition, all the while shedding energy and increasing entropy but locally concentrating metals. This set me on a journey from about 2015 to try and understand mineral systems better. Strangely enough through this journey I now understand that Hronsky's model is limited, likely flawed, and better models exist to explain ore geosystem phenomena.

In 2015, I organised the first workshop retreat to address learning more about systems thinking and applications in exploration geoscience. Whilst trying to go from zero to hero in one weekend, we did have a lot of fun. One of the participants, Deborah Lord, connected the group to an environmental systems scientist at CSIRO named Ashley Sparrow. We followed up with a Saturday at University of Western

Australia to listen to Ashley and think about applications in geoscience. I did not know then what I learned at NECSI course this February, 2024, that is the Law of Universality. This systems "law" is what makes all knowledge useful.

What is the Law of Universality?

The Law of Universality is at the core of understanding complex systems that are all around us. Put simply the law says that it is possible to understand a variety of patterns and behaviours in different systems as they often share the same underlying concepts. This is where Ashley's contribution to our story fits in.

At the core of Universality is scale. As we move up scales in complex systems, we start to see the important simple rules that give rise to the diverse patterns. That is to say there are only a few properties that are important at a larger scale perspective, that you can never map all the details and you don't need to.

Further, it also means that gathering diverse groups of people together who have knowledge gained in different disciplines, life experiences or cultures is probably the best way to make progress in understanding systems, how patterns form, and what are the key leverage points for change or impact.

So, we can take ideas from other disciplines to understand the patterns in, say geology and mineralising systems.

This should be considered a key breakthrough in progressing the understanding of complex geosystems. It means we can look at a science like

astronomy that has been around for several thousand years and apply some of the principal rules to solving the problems in geology, a science that is only 200 years old. It also means that the progress that was made in social, biological, financial and ecological science over the last 50 years should be able to be applied to understanding the behaviour and patterns in geosystems and mineralising geosystems. Knowing anything suddenly becomes useful!

As “discovery scientists” who study complex mineralising systems, we need to work out the things that truly matter, what is important and what is not, and study and treat these important things carefully. As a blog commentator reminded me, Steve Jobs once said, “Innovation distinguishes between a leader and a follower.” Applying principles from various disciplines to understand complex systems truly embodies this spirit of innovation. I now believe that this approach to bridging gaps across different fields will lead to more discoveries.

Complex Systems thinking encourages a focus on emergent phenomena

Complex Systems thinking encourages a focus on emergent phenomena – patterns and behaviours that arise from interactions among system components. By understanding the underlying mechanisms driving emergence, we can identify opportunities for innovation.

This involves fostering condi-

tions (organisational culture) that promotes serendipity, diversity, and experimentation within the system. There is an ongoing exploration of how to innovate in systems, i.e. acknowledging that the linear way of innovating does not work in complex situations and for transforming systems. A systemic approach to thinking invites the innovation community to apply for funding aimed at establishing ecosystems or platforms dedicated to challenge-based, adaptive innovation. Systemic innovation should be adaptive, and the most adaptive way to organise innovation processes is in an innovation ecosystem. Such a system can embrace all the actors needed for handling the complexity (industry, research institutions, public agencies, civil society, and media, among others). This brings me to my next growth stage, when I became a member of Systems Innovation, and worked through their excellent online courses and eBooks (<https://www.systemsinnovation.network/about>).

Ecosystems like SI can inspire portfolios of interventions and activities, bringing together all actors and stakeholders that are needed for change, spanning from industry, research institutions to public sector, government and communities. If rigged for the long-term, as they can orchestrate collaboration across sectors, and collaborations that must continue even after a project ends.

The long-term perspective of an ecosystem, and the actors within it are both beneficiaries when it comes to scaling new innovations.

However, as this work involves paradigm shifts for others to engage and change thinking the final driver of acceptance and change will be deeply human and social in its nature. Change affects people, and paradigm shifts affect things such as they never go back to how they were. In Geoscience the greatest paradigm shift in my lifetime was the advent of Plate Tectonics Theory which arguably has changed all geologist world views of how the Earth works.

Whatever the new idea, difficulties usually come from scaling up from pilot projects, like the first stock and flow mineralising systems map for Hercynian Tin deposits. People are resistant to change and new perspectives. This is often due to the absence of essential actors within their environments to incentivise and lead change. The key is to grow a well-integrated ecosystem, where relevant stakeholders can be engaged as needed, and the composition of stakeholders can evolve in tandem with the concepts progress. This is where the idea for “Thinkercafe” came from, to corral some of the best thinkers in Australia to build, review and model the new way. I am grateful to all those who have participated in this initiative and journey.

So where to next? We need to follow The Five Answers

So where to next? This is where we need to go as an industry. We need to follow The Five Answers.

Unearthing Riches: The Five Answers for Mineral Discovery (from my LinkedIn Blog, March 2024) and

<https://www.thinker.events/blog/tim-craske-the-5-answers-for-discovery/>

Mineral discovery intertwines science, exploration, and economics. It's a pursuit that has shaped civilizations, driven technological advancements, and fuelled economic growth through history. But what are the keys to uncovering resources beneath the Earth's surface? The answers lie in a comprehensive framework encompassing cultural values, paradigm shifts, systems thinking, access to ground, and access to financial resources.

1. **Culture:** The culture of your organisation, or if you are a solopreneur, the culture gained through a career of different roles with a spread of employers, has more influence on your chance of discovery than any other factor including geological understanding. It speaks to supporting risk taking, persistence, curiosity and collaboration. This is a greater factor than good geology skills. Culture can inhibit or accelerate new prescience leading to paradigm shifts.
2. **Paradigm Shift:** Successful mineral discovery often hinges on a paradigm shift – a departure from conventional wisdom or outdated geological models or a new search space. Embracing innovative technologies and unconventional theories, can revolutionise the way we perceive and explore regions or identify new greenfield search spaces. A willingness to challenge existing paradigms opens doors to new frontiers of discovery.

3. **Systems Thinking:** Mineral exploration is inherently complex, requiring a holistic understanding of geological, environmental, and socio-economic systems (“value chains”). Systems thinking enables geologists to map the interconnect- edness of various factors influenc- ing mineral deposit location, scale and grade. By adopting a systemic approach we can identify patterns, anticipate challenges, predict the size of a deposit from only one or two drill holes and identify loca- tions of missing ore nodes in a network of hydrothermal deposits, thereby optimising project progres- sion through the portfolio pipeline.
4. **Access to Ground:** Securing access to prospective land is fundamen- tal to exploration success. Whether through land acquisition, part- nerships, or government permits, gaining permission to explore and extract minerals is a critical prereq- uisite. Collaborating with landown- ers, regulatory authorities, and local stakeholders facilitates responsible exploration practices and high ESG ratings, while maximising the po- tential for discovery. Working on second grade ground because you cannot deal with stakeholders con- trolling your primary targets means that you will be much less success- ful in the short and likely the long term. However, building relation- ships with landholders and first nation traditional owners can be facilitated by working in a district and building trust over time to gain access to your primary targets.
5. **Access to Money:** Mineral explora- tion demands substantial financial investment, from initial prospecting activities to drilling and feasibility studies. Access to capital is essen- tial for funding exploration cam- paigns, acquiring equipment, and sustaining operations in remote and challenging environments. Private investors, government grants, and venture capital play pivotal roles in financing mineral exploration ven- tures, ensuring the resources need- ed to pursue discovery opportuni- ties. You need to build bridges to all these sources of funds. Without consistent funding projects slow, stagnate and investors lose faith and patience.

The Five Answers is a complex system-based model providing a com- prehensive roadmap for navigating the complexities of exploration to discover valuable mineral resources, underscor- ing the enduring significance of mineral exploration in shaping our world. From a complex systems perspective, think- ing in the resources sectors needs to match the complexity of the challenges ahead. In the clean energy transition, we all must address complex challenges and the exploration and the extraction industries will need to play their part in mitigating climate change as well as providing the materials for the clean energy transition. The Resources Sector has to deal with complexity, and the ex- ploration arm of the sector needs to be the leaders in this area. In essence, ex- plorers cannot afford to operate without a systems-thinking mindset.