



Delivering geological and exploration outcomes in underexplored regions

Application of advanced drilling capabilities and collaborations with Geological Surveys

by **Andrew Bailey**, CEO of MinEx CRC

A series of National Drilling Initiative (NDI) campaigns led by the Mineral Exploration Cooperative Research Centre (MinEx CRC) during 2024-2025 have delivered new pre-competitive geological data beneath deep cover in Western Australia and South Australia, advancing understanding of mineral systems, tectonic evolution, and basement geology across underexplored regions.

The campaigns were delivered in partnership with third party service provider DIG CT, operating the CT500 coiled tubing rig as a sub-contractor to MinEx CRC, and in collaboration with the Geological Survey of Western Australia (GSWA) and the Geological Survey of South Australia (GSSA).

The first campaign was undertaken in the immediate area of the Nifty Copper deposit in northwest WA, in collaboration with GSWA. The second was conducted in the northern Gawler Craton in South Australia, in collaboration with the GSSA.

National Drilling Initiative: A collaborative approach to frontier exploration

MinEx CRC is Australia's national mineral exploration collaboration, bringing together industry, government Geological Surveys, and research organizations to transform the way exploration is conducted under deep cover. A core component of this mission is the delivery of large-scale NDI campaigns, a world-first collaboration of Geological Surveys, researchers, and industry, to undertake drilling in underexplored areas of potential mineral wealth and to provide a test-bed for new mineral exploration technologies.

The NDI program is focused on stimulating exploration investment by providing publicly available datasets that reduce uncertainty in frontier terrains. Through the NDI, MinEx CRC deploys innovative drilling technologies, including coiled tubing (CT) systems, to improve drilling efficiency, reduce costs, and minimize environmental impact while maximizing the geological information returned to industry and government.

The CT drilling applied is a safer method of drilling. It is fluid driven, negating the need for high pressure air, and the continuous coil avoids instances of dropped rods. In addition, the CT rig has a smaller footprint and uses significantly less fuel and water, thus delivering meaningful cost savings. Sample recovery is excellent, and the CT rig has the ability to do a short core run at any stage of the drill hole.

The CT500 coiled tubing rig, optimized through MinEx CRC research, allows for deeper, steerable drilling that delivers the highest quality sampling at up to one fifth of the cost of conventional diamond drilling.

Nifty NDI: Extending geological insight in the Yeneena Basin

The Nifty campaign was a continuation of the drilling program which began in 2023, with drilling resuming in July 2024 and running through to early September 2024. Three additional drill holes were completed during this period, bringing the Nifty campaign to a total of 3129 m (10 266 ft) drilled across nine holes.

In addition to new CT drilling, the Nifty NDI campaign involved relogging and sampling legacy drill material from the ore body, as well as from host rocks (within hundreds of meters) and more distal parts of the mineral system (up to tens of kilometers from the deposit).

The samples were subjected to an integrated suite of analytical techniques aimed at characterizing and dating key elements of the Nifty mineral system, which is primarily a target for copper exploration.

Mineralogical and geochemical analyses reveal multiple, overprinting mineralization events at the Nifty deposit that are associated with sedimentary and diagenetic processes. Coarse-grained chalcopyrite mineralization reflects dynamic remobilization events that post-date the basin formation.

Analysis of stable isotopes, including both traditional (e.g. oxygen and carbon) and novel (e.g. copper isotopes), from ore, gangue, and host rock minerals, support the interaction of at least two discrete fluid sources in the formation of the Nifty mineralization.

Preliminary fluid inclusion data further suggest that the fluid associated with chalcopyrite mineralization was with a relatively lower salinity and a higher temperature than formation waters associated with pre-ore processes.

The geochemistry of apatite associated with the ore body shows a characteristic hydrothermal signature, including depleted light and heavy rare earth elements, elevated mid-range rare earth elements, and a positive europium anomaly.

In-situ Rb-Sr geochronology is consistent with a post-basin fluid flow event associated with the ~680-610 Ma Miles Orogeny.

Finally, a synthesis of petrophysical data across the Yeneena Basin, the host basin of the Nifty deposit, included assessment of data quality. This was necessitated by the various acquisition and processing techniques used to collect legacy datasets.

Prospectivity modeling across the Yeneena Basin

Prospectivity modeling across the Yeneena Basin using both knowledge-driven (fuzzy logic) and data-driven approaches has also been completed. The knowledge-driven approach integrates geological and geophysical data to create fuzzy logic-based prospectivity maps, while the data-driven approach uses machine learning algorithms to analyze spatial data layers and predict mineralization potential.

Key findings of the prospectivity modeling include the identification of highly prospective zones for copper mineralization, particularly in areas with a high density of structures and proximity to source rocks. The modeling also demonstrates the effectiveness of available datasets as proxies for mappable criteria within the knowledge-driven approach. In contrast, application of the data-driven approach highlights the challenges associated with limited and biased training data, underscoring the need for more representative datasets and rigorous model validation.



↑ CT500 coiled tubing rig deployed during the Northern Gawler Craton NDI Campaign, Mt Barry Station, South Australia

▶ The current study will be continued with geochemical-mineralogical modeling to test conceptual multi-stage models of Nifty sediment-hosted copper mineralization and to constrain the source and controlling factors of copper precipitation.

Northern Gawler Craton NDI: Accessing basement beneath thick cover

Following the Nifty NDI campaign, the CT drilling platform was mobilized to South Australia, where DIG CT completed 2309 m (7575 ft) of drilling across seven drill holes. The program delivered high-quality cuttings samples through hundreds of meters of cover material, cored basin-sediment intervals in two holes, and intersected basement in five holes.

Cover thickness ranged from around 300 to over 430 m (around 984 to over 1411 ft), demonstrating the operational capability of CT drilling to access basement geology in remote regions dominated by deep cover.

The drill holes penetrated young (approximately 300–100 million year old) sedimentary cover sequences prior to intersecting older basement rocks. Of particular significance was the recognition of diamictite at the base of the cover sequence in several holes. This poorly sorted sediment contains both locally derived basement clasts and well-traveled glacial erratics, providing a useful regional stratigraphic marker and insight into the early evolution of the sedimentary sequences.

Basement lithologies recovered during the campaign are dominated by felsic rocks that have been subject to high grade metamorphism. Several holes intersected strongly deformed intervals associated

with large-scale shear zones that separate major geological domains. Geochronological results from both legacy core and new NDI samples indicate magmatic crystallization with ages of approximately 1720–1750 million years for the basement rocks and provide evidence of multiple younger metamorphic events.

Integrated downhole logging and hyperspectral analysis

The campaign placed strong emphasis on integrated data acquisition. Downhole wireline logging, including total count gamma and magnetic susceptibility, proved particularly valuable in differentiating lithological and mineralogical changes that were not always visually apparent in core or cuttings. Geological logging was supported by systematic cuttings and core photography, portable XRF geochemical measurements, and subsequent HyLogger hyperspectral scanning. Together, these datasets significantly improved confidence in stratigraphic and lithological interpretation beneath deep cover and highlight the value of combining downhole sensing with physical sampling in NDI-style programs.

New insights into tectonic history and mineral potential

Drilling samples from the Gawler NDI were transported to Adelaide for analysis with HyLogger and were made available for logging, sampling, and analysis as part of the South Australia Drill Core Library's public collection. The samples collected were subjected to a range



↑ Geological sampling during the Northern Gawler Craton NDI Campaign, Mt Barry Station, South Australia

of analyses, including petrology, geochronology, isotopic tracing, mineral chemistry, and petrophysics.

As part of the project, complementary analyses were also conducted on legacy drilling samples from the northern Gawler Craton. Combined geochronology and petrological modeling has already delivered new insights into the tectonic history and the potential timing of mineralization events in the northern Gawler Craton.

Together, the data collected from new NDI holes and legacy drill core has enabled characterization and mapping of the basement rocks in the northern Gawler Craton, deepening the understanding of its geological history and identifying areas of mineral prospectivity, stimulating new exploration in this part of the state.

While the NDI program is stratigraphic in nature and not designed to target economic mineralization, early geological observations provide important context for regional mineral systems analysis. The presence of pyrite, quartz veining, and high-grade metamorphic fabrics in several basement intersections indicates a history of hydrothermal fluid activity, particularly along shear zones. These features are consistent with emerging models that suggest the northern Gawler Craton has experienced multiple mineralizing and tectono-thermal events, distinct in timing and character from the Olympic Dam-style iron oxide-copper-gold (IOCG) systems developed further south.

Accelerating discovery through national collaboration

A workshop to present the data collected from the Northern Gawler NDI, along with comprehensive studies from legacy drill holes in the

northern Gawler Craton region collected as part of the SA Discovery Mapping Project, was held in December 2025.

The data has also been made available to the public via the South Australian National Drilling Initiative Dashboard. The dashboard presents drill hole data in visual format using simple drop-down menus and provides access to a metadata download link from which the raw data can be downloaded.

The integration of datasets produced by applying modern analytical techniques on MinEx CRC's NDI samples and legacy drill core has shown how innovative drilling approaches such as CT drilling and strong partnerships with geological surveys create a lasting, nationally significant archive of data and samples. This accelerates geological understanding of complex terranes, reduces exploration risk, and helps to unlock Australia's mineral potential beneath deep cover. In doing so, the NDI program delivers enduring value well beyond the life of the drilling campaign, informing smarter exploration decisions and supporting future discovery beneath deep cover.

Planning is underway to conduct NDI campaigns in the Cobar region of NSW through 2026, with results expected to be publicly available in 2027. 🇺🇦

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