The African continent is home to crustal rocks that span the earth’s geological history and host enormous mineral wealth, but it has remained for the most part relatively underexplored. However, new technologies for exploration and extraction, combined with modern data processing techniques, could change all that.

Africa’s oldest rocks, called the Archaen cores of the cratons, host world-class sedimentary deposits of gold and uranium in South Africa, and widespread smaller shear zone hosted gold deposits on most of the cratonic core areas. These areas are also known for preserving:

- The younger sedimentary rocks that were deposited on them – e.g. Proterozoic basin sediments – containing world-class iron and manganese deposits (Cameroun, Gaben, Guinea, Sierra Leone and South Africa);
- Igneous rocks that intruded the cratons throughout geological history, such as the large layered ultramafic-mafic complexes including the Bushveld Complex in South Africa, the Great Dyke in Zimbabwe with platinum group elements (PGEs), chrome and vanadiferous ilmenomagnetite; and
- Kimberlite pipes, some with diamond mineralisation in all the cratonic cores that eroded to give rise to alluvial and marine diamond deposits in Namibia.

The cratons’ cores are welded together in the larger cratons by Proterozoic Mobile Belts. The supra-crustal rocks host sedimentary base metal deposits such as the central African copper belt in Zambia and DRC, and the copper-lead-zinc deposits of the Namaqua Province in South Africa and Namibia, and the Damara Province of Namibia and north-western Botswana.

Granite-associated uranium and tin deposits occur in Namibia, Nigeria and Rwanda-Burundi, tantalum in Ethiopia, graphite in Kenya, Tanzania and Mozambique, while the Nubian shield represents a different target for gold deposits. Carbonatite complexes, in some instances directly related to rift systems or extensions of ocean floor transform faults onto the continent, host copper in South Africa, fluorite in Namibia, niobium and tantalum in Tanzania and Kenya, phosphate and vermiculite deposits in South Africa and Uganda, and may form important repositories of rare earth elements.

The stitching together of the cratons was responsible for the formation of a supercontinent known as Gondwanaland, large inter-continental sediment-filled basins formed during the Palaeozoic and Mesozoic. The best example of this is the Karoo basin, with coal seams towards the base of the sequence in Southern Africa. Palaeozoic sedimentary uranium deposits occur in Chad and South Africa.

**Treasures of the African Land Surface**

Following the breakup of Gondwanaland was the formation during the Mesozoic of the African Land Surface. This surface is related to a deep and extensive weather-
ing profile resulting in pedogenic limestone deposits in South Africa, bauxite deposits in Central and West Africa, the development of pedogenic high grade manganese deposits in Gabon, and nickel laterite deposits in Madagascar.

This land surface also acted as a staging phase for the redistribution and concentration of alluvial diamonds, other gemstones, gold, and large heavy mineral deposits of titanium and zirconium in Kenya, Mozambique, South Africa and Tanzania, as well as marine diamond deposits in Namibia and South Africa and large phosphorite deposits in Egypt, Morocco, South Africa and Tunisia.

There are a number of reasons why Africa still has extensive exploration potential. These include the thick cover from deep weathering during the Mesozoic, with relatively minor denudation since then. Also, there is extensive cover formed by Cenozoic sediments, and the relatively hostile environments in the equatorial forest of central Africa and the desert areas of the continent have impeded exploration efforts.

**Why could that change now?**

Large parts of the continent have remained relatively inaccessible for exploration companies during the post-colonial period. However, there has been enormous development in the ability to collect and process information.

The sensitivity and efficiency of geochemical and geophysical tools has been greatly improved, leading to lower detection limits with reduced measurement times; these tools have also become much smaller and more user-friendly.

In addition, remote sensing and satellite methodologies now provide accurate geospatial location and multispectral coverage that can be integrated with geological, tectonic, geophysical and geochemical information.

For geochemistry, the biggest advances in field equipment have been continuing improvements in the portable X-ray fluorescence (XRF) for chemical analysis, and in infra-red and near infra-red spectrometry, as well as X-ray diffraction tools, for mineral identification and quantification. If used responsibly, such instruments can dramatically reduce turn-around time on sample analyses, rapid redirection of sampling programmes, target selection and follow-up exploration.

**Technology still relies on professional skills**

The greatest challenge facing the modern explorer is inadequate training and experience in processing and interpreting large data sets, as well as a limited understanding of sampling theory, geochemical associations, mineral chemistry and the chemical processes in the primary ore forming and secondary weathering environments.

It should be remembered that the easy mineral targets have already been found. This makes the new advances discussed here hugely significant, if they are coupled with advanced exploration and data processing methods. In fact, some of the historical statistical methods used need to be 'rediscovered'.

There are modern hyperspectral methods that may be used in the indicator mineral identification and quantification in airborne, soil, core and chip sample applications. Exploration geochemistry is at a new dawn, and the role of the well-qualified, experienced geochemist is becoming ever more important.

**Significant advances**

Significant advances have been made in airborne, ground and wireline geophysical acquisition, as well as in data processing techniques. The innovations in airborne methods are particularly relevant to exploration in Africa because of the improved depth penetration through conductive cover. The airborne methods cover a range of techniques such as magnetics, electromagnetics, radiometrics, gravity gradiometry and georadar, some of which can be applied simultaneously. There have even been advances in an airborne induced polarisation (IP) system, a method that has traditionally required ground contact.

Data processing methods have improved significantly, enabling the reprocessing of legacy data using new interpretation and modelling techniques. Joint inversions of previously disparate data sets are now possible – for example, with gravity and seismic disparate data – resulting in an improvement in resolution, better constrained models and reduced uncertainties.

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