New Data on the Diamond Potential of the Proterozoic Sedimentary Sequences in the Save River Basin, Manicaland Province, Zimbabwe

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PROSPECTING WORKS

- Eastern Zimbabwe is of considerable interest for diamond exploration owing to the development of Mesoproterozoic sedimentary successions of the Umkondo Group, which host significant palaeoplacer diamond occurrences and deposits, including the Marange–Chiadzwa and Chimanimani deposits.
- Alrosa (Zimbabwe) company conducted an exploration program to search for a new diamond deposits on their licenses in the south-west of the country (Manicaland province) during the period 2022 to 2024.
- In this province, ALROSA (ZIMBABWE) Ltd. has received 11 special grants, covering a total area of 77,500 hectares.

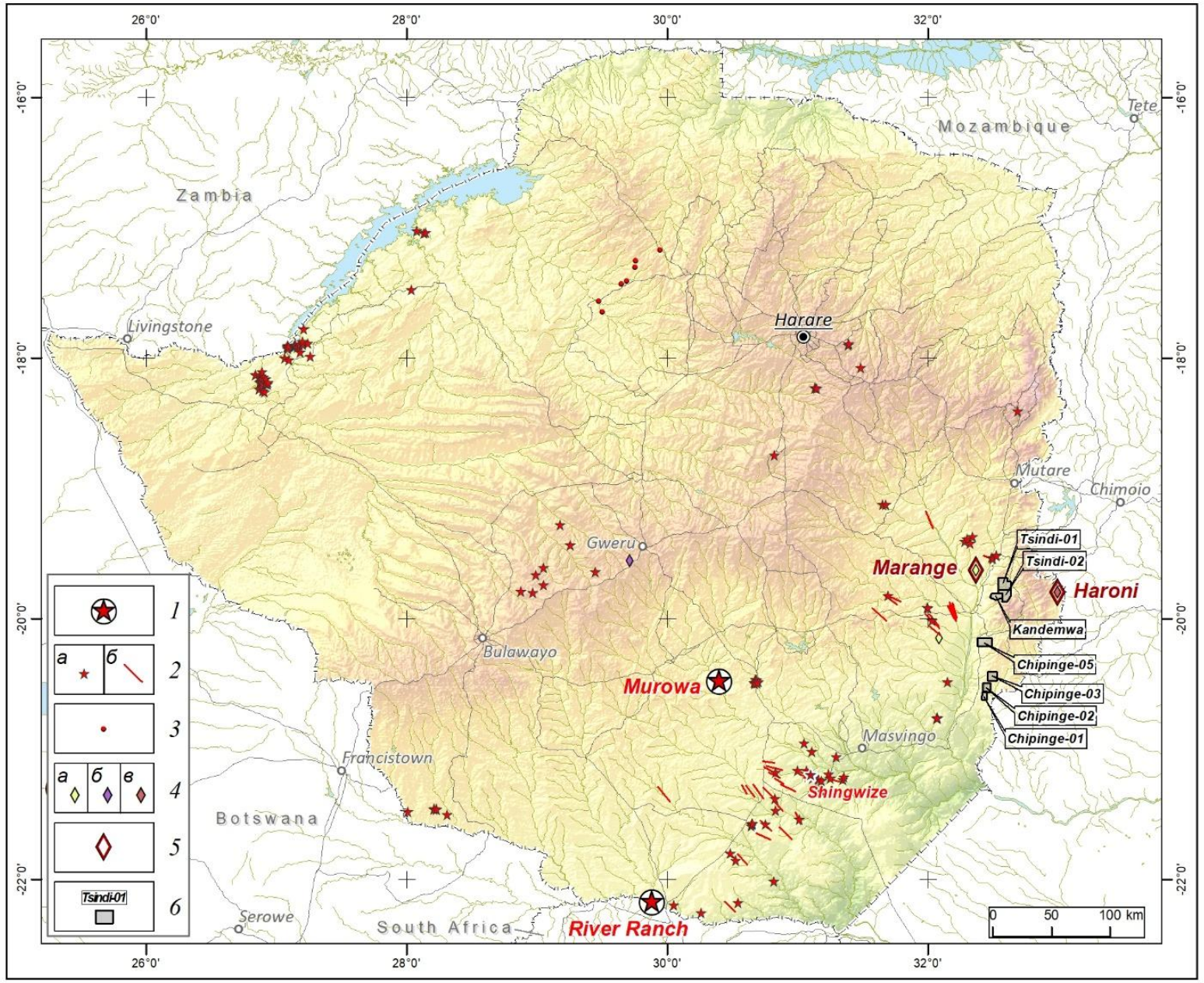


Fig. 1. The map of Zimbabwe with defined location of the prospecting licences for diamonds of Alrosa (Zimbabwe) in Manicaland province.

1 - Diamond deposits; 2 - Kimberlites; 3 - Related rocks; 4 - Alluvial placers; 5 – Diamond placers.

REGIONAL GEOLOGY

Granite-Gneiss Basement (Zimbabwean Craton):

- The granite-gneisses dated at 2,7 Ga by Manhica et al (2002) (range 3,0-2,6 Ga);
- The eastern edge of the Zimbabwean craton flanked by the north-south Mozambique belt which includes both 0.6-0.5 Ga and 1.1 Ga tectonic age. It means it records the collision event during the assembly of Rhodia (1.1 Ga) and Pan African event also.
- The southern edge of the craton flanked by the North Marginal Zone of the Limpopo belt.

Umkondo Group sediments (1,1 Ga):

The Umkondo Group sediments form a supracrustal sequence which unconformably drapes over the eastern margin of the Zimbabwean craton. The sequence has been subdivided into two distinct facies (the Zimbabwean facies in the west and Mozambique facies in the east) that are largely believed to represent lateral facies equivalents (Stocklmayer, 1981).

Umkondo igneous event (Dolerites/Basalts):

- Represented by dolerite dykes, thick sills, and minor outcrops of basalt flows;
- Umkondo igneous event was temporarily associated with the end of the Umkondo basin development. Allsopp et al. (1989) has dated these dolerites at - 1.15 Ga.

Save rift:

- Save rift Save River is ascribed to this late Gondwana-age rifting.

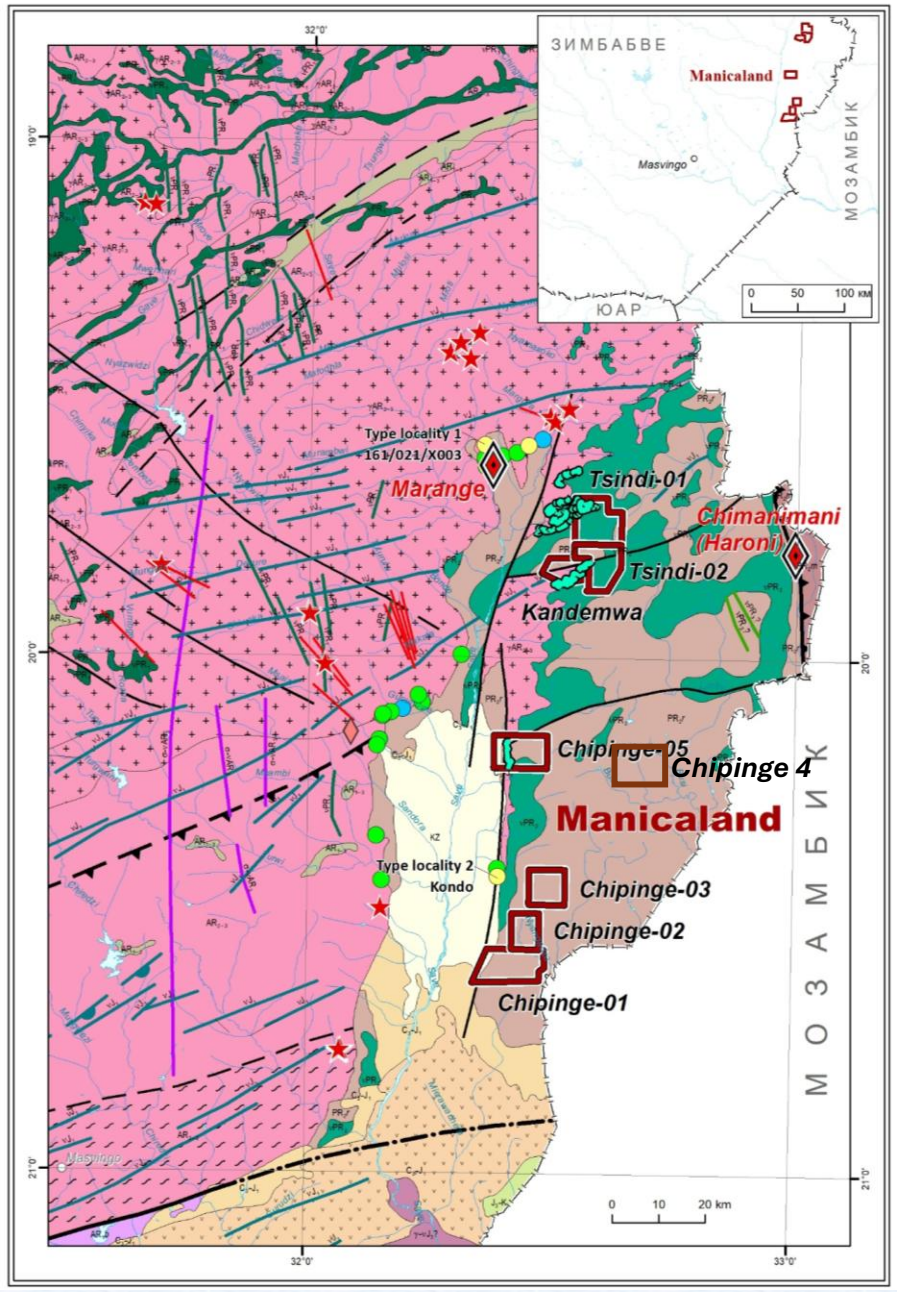


Fig. 2. Geological map of Eastern Zimbabwe

REGIONAL GEOLOGY

Marange:

- The diamondiferous nature of the Marange area is primarily associated with basal conglomerates of the Umkondo Group (1.1 Ga);
- The eluvial, deluvial and modern alluvial diamond concentrations are secondary on their origin.

Chimanimani:

- The Chimanimani diamondiferous sediments occur higher in the stratigraphic succession of the same Umkondo Group (1.1 Ga);

<u>For diamond exploration the prospective target is the Proterozoic sedimentary collectors of the Save River Basin.</u>

- On this map you can see the outcrops of the Umkondo basal arkoses identified and sampled by De Beers Geologists (green and yellow dots).
- You can see also the outline of the areas explored by the Alrosa team during our prospecting works.

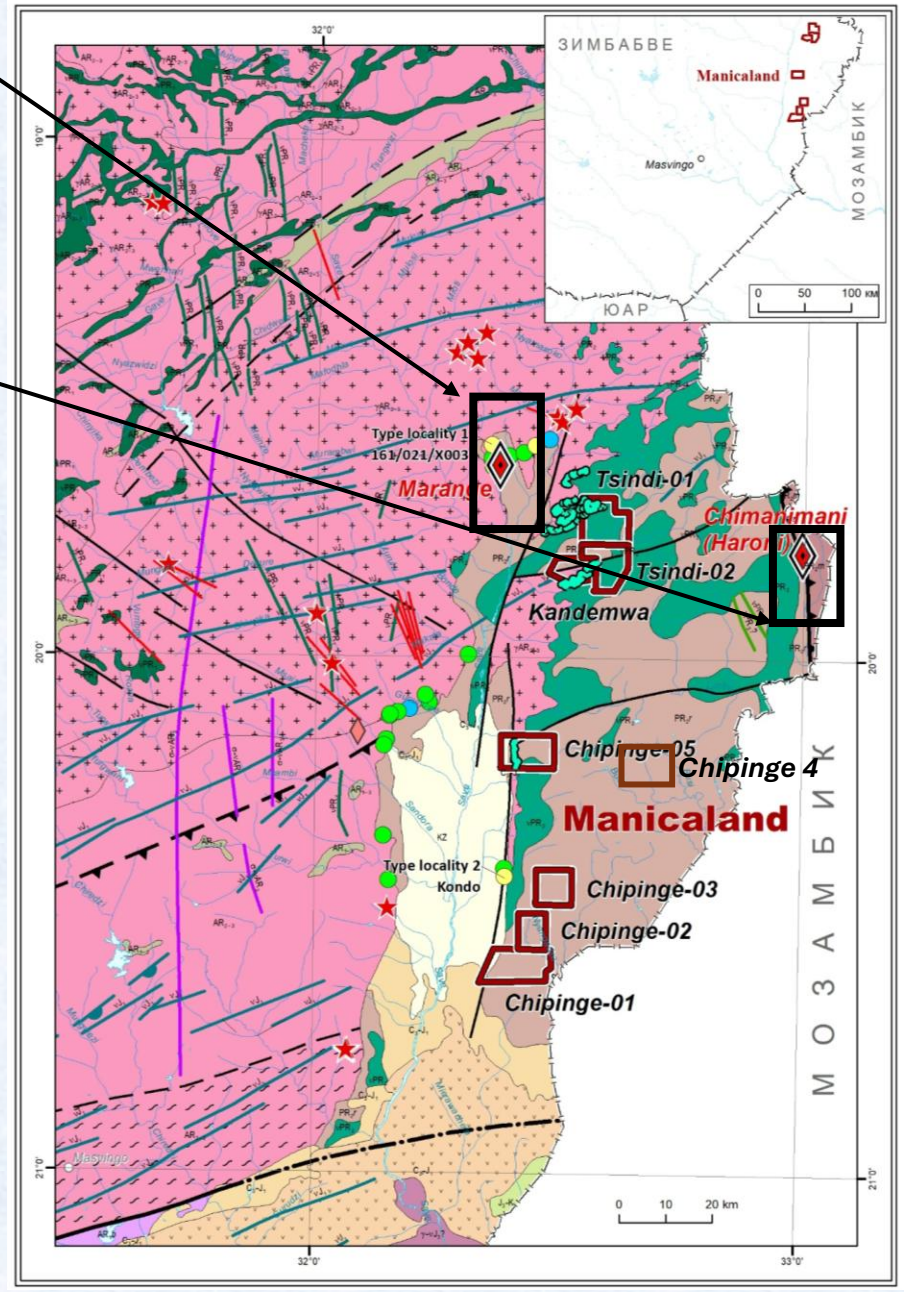
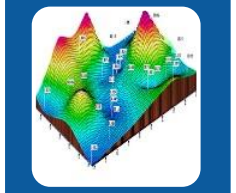


Fig. 3. Geological map of Eastern Zimbabwe

PROSPECTING WORKS

During 2022–2024, ALROSA's team conducted diamond exploration within the Save River Basin and adjacent areas of Manicaland Province.

The exploration programme comprised:

	• Geological mapping; • Heavy-mineral stream sampling • Mineralogical studies
	• RPA Topographic surveys • RPA Aeromagnetic surveys
	• Bulk sampling of coarse-grained basal deposits of the Umkondo Group; • Diamond Drilling.
	• Microprobe determination of the chemical composition of kimberlitic indicator minerals (chromites, picroilmenites and clinopyroxenes);





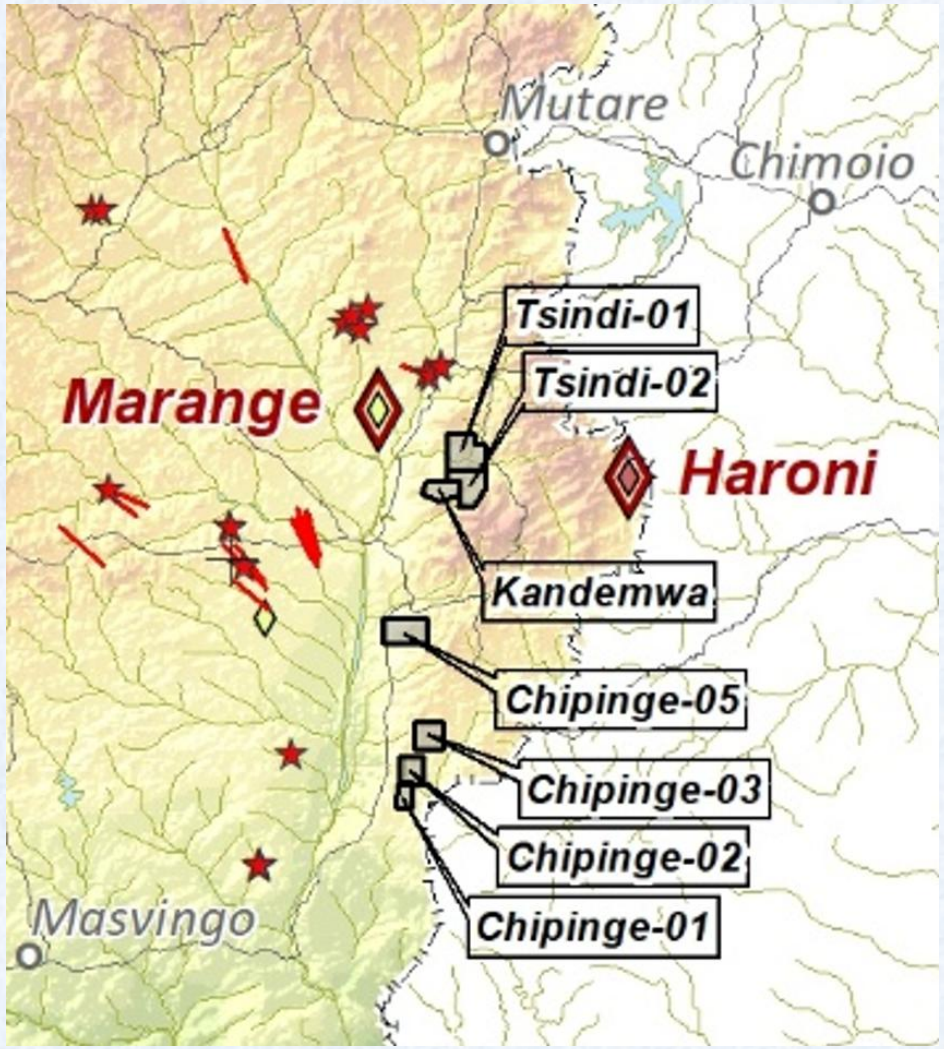
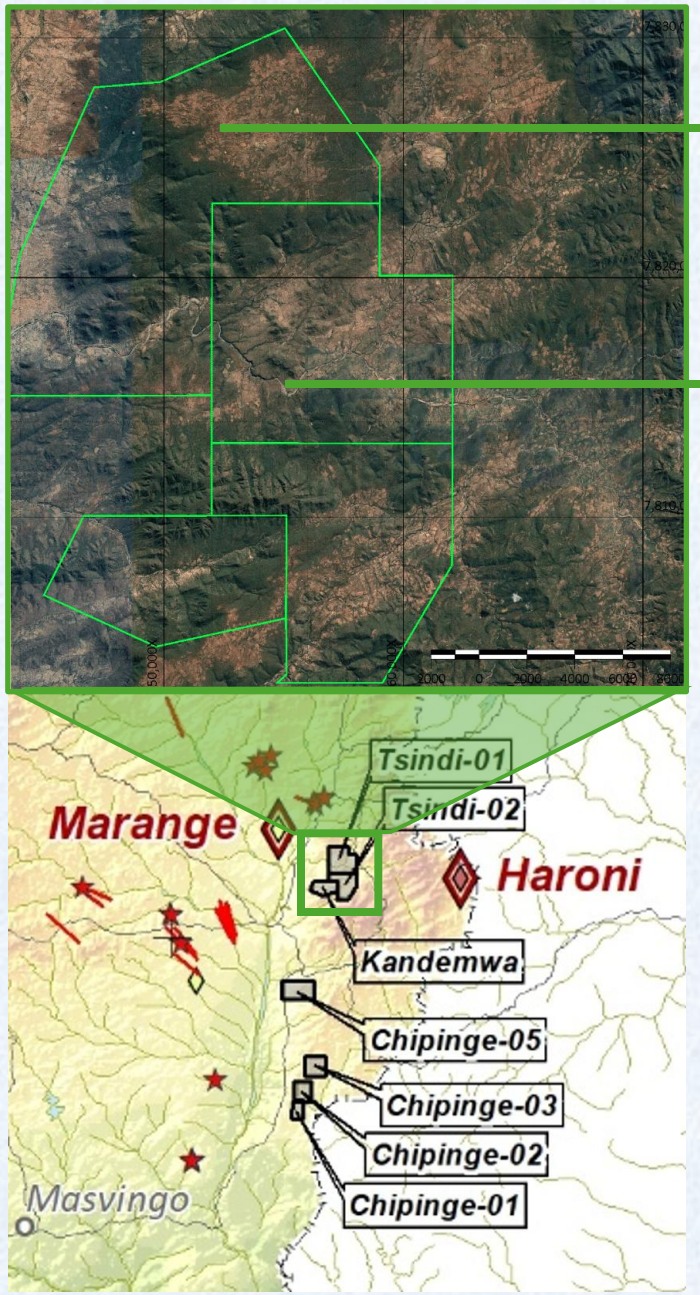


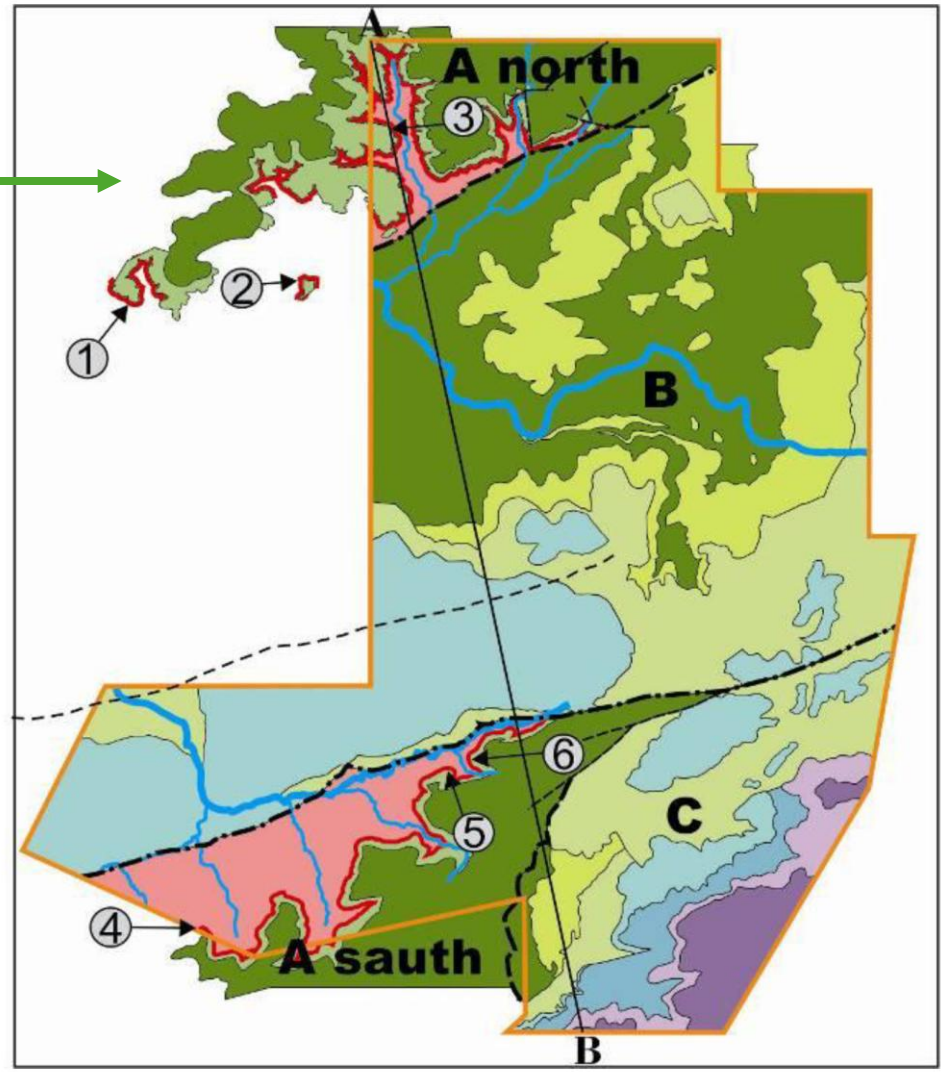
Fig. 4. Location of exploration sites.

GEOLOGICAL MAPPING, TSINDI AREA

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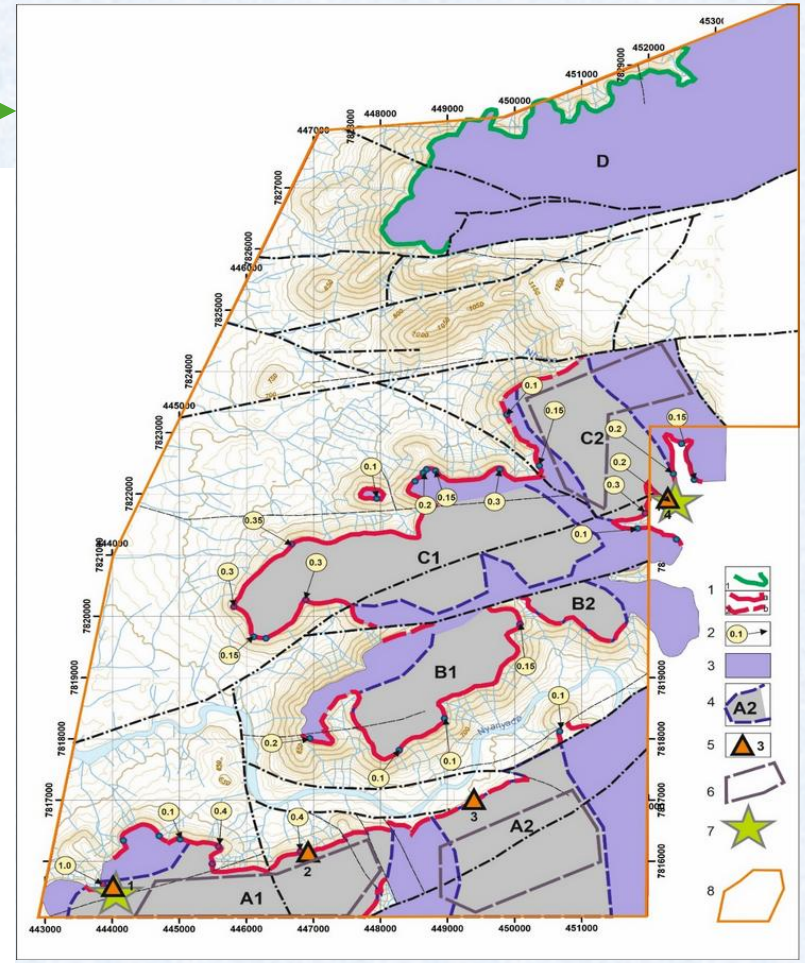
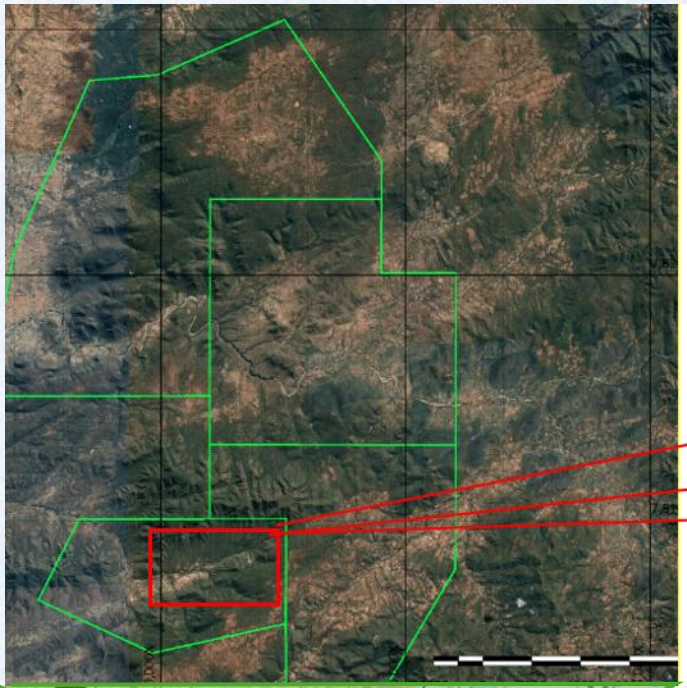


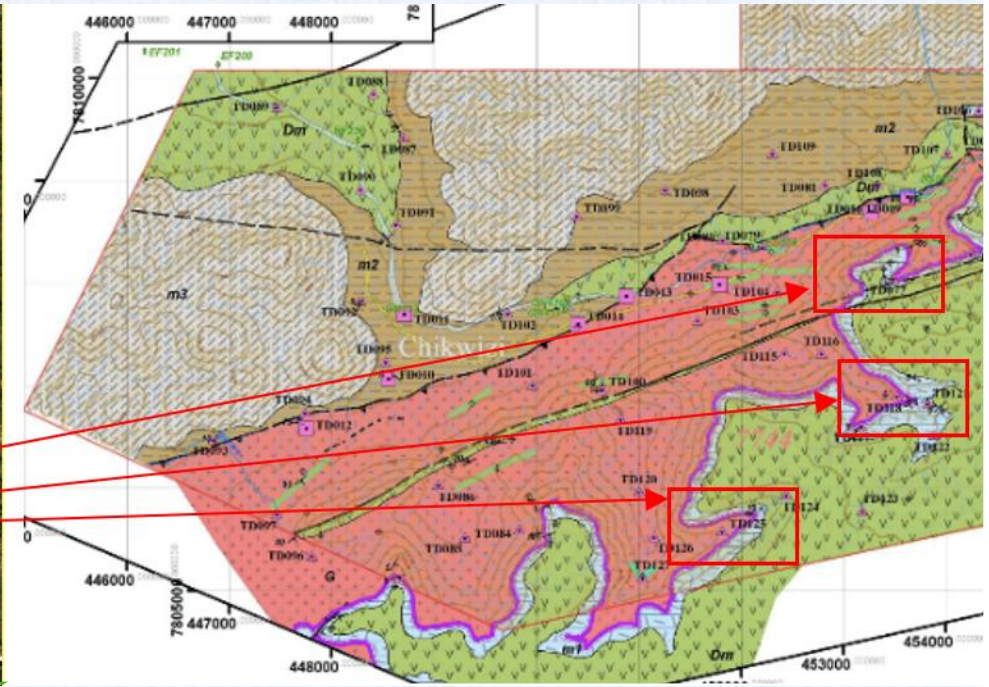
Fig. 5-6. Schematic maps of diamond potential forecast (Tsindi and Hot Springs area). Outcrops of potentially diamond-bearing coarse-grained basal parts of the Umkondo sediments are marked by a red line.

BULK SAMPLING, TSINDI AREA

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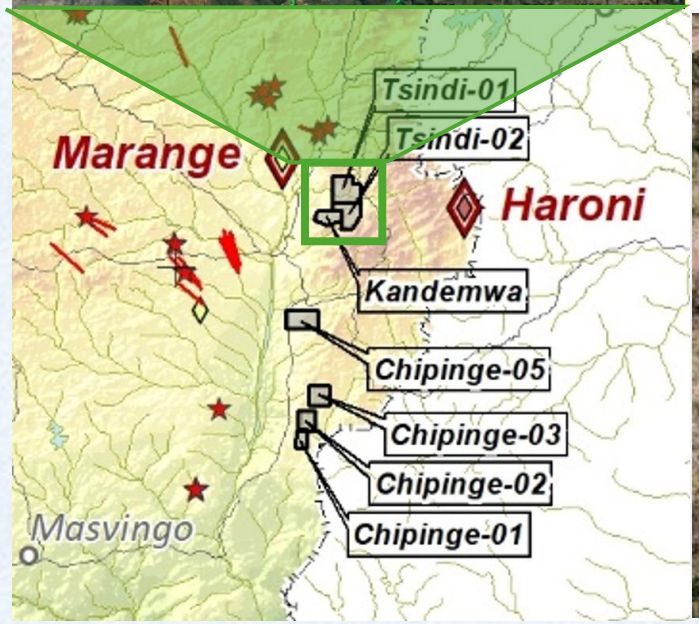






Fig. 7. Bulk sampling site in the Umkondo conglomerates (top). 3D model of the sampling site based on UAV imagery (left).

BULK SAMPLING, TSINDI AREA



Fig. 8. View of the sampling area from a height of 100 m (plan view, photo on the left); The bulk sampling area following the first stage of blasting operations—removal of the overburden (photo on the centre); The top surface of the Umkondo basal conglomerates during blasting preparation (photo on the right).

BULK SAMPLING, TSINDI AREA







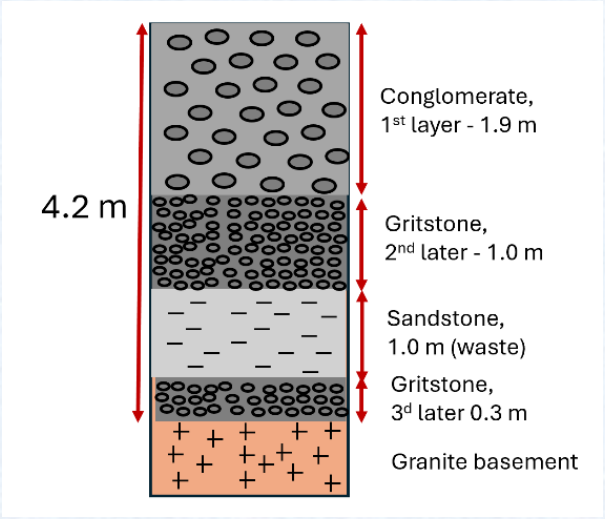


Fig. 9. Another bulk sampling site. Preparation for blasting is in progress.



DRILLING, TSINDI AREA

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The next step was to delineate the area of extension of this diamond-bearing rock.

- 18 combined-drilling (RC+DD) holes of 1,300 linear meters in total were drilled to map the coarse-grained Umkondo sediments.
- Each drill hole has intersected the top sedimentary layer, occasionally dolerite sills, then the basal arkose horizon, and has finished in basement granites.
- Drilling have revealed that the "areal" distribution of conglomerates was not confirmed. The conglomerate occurrences exhibit a more complex structure, corresponding instead to localized zones—such as channels or accumulation areas within the placers.

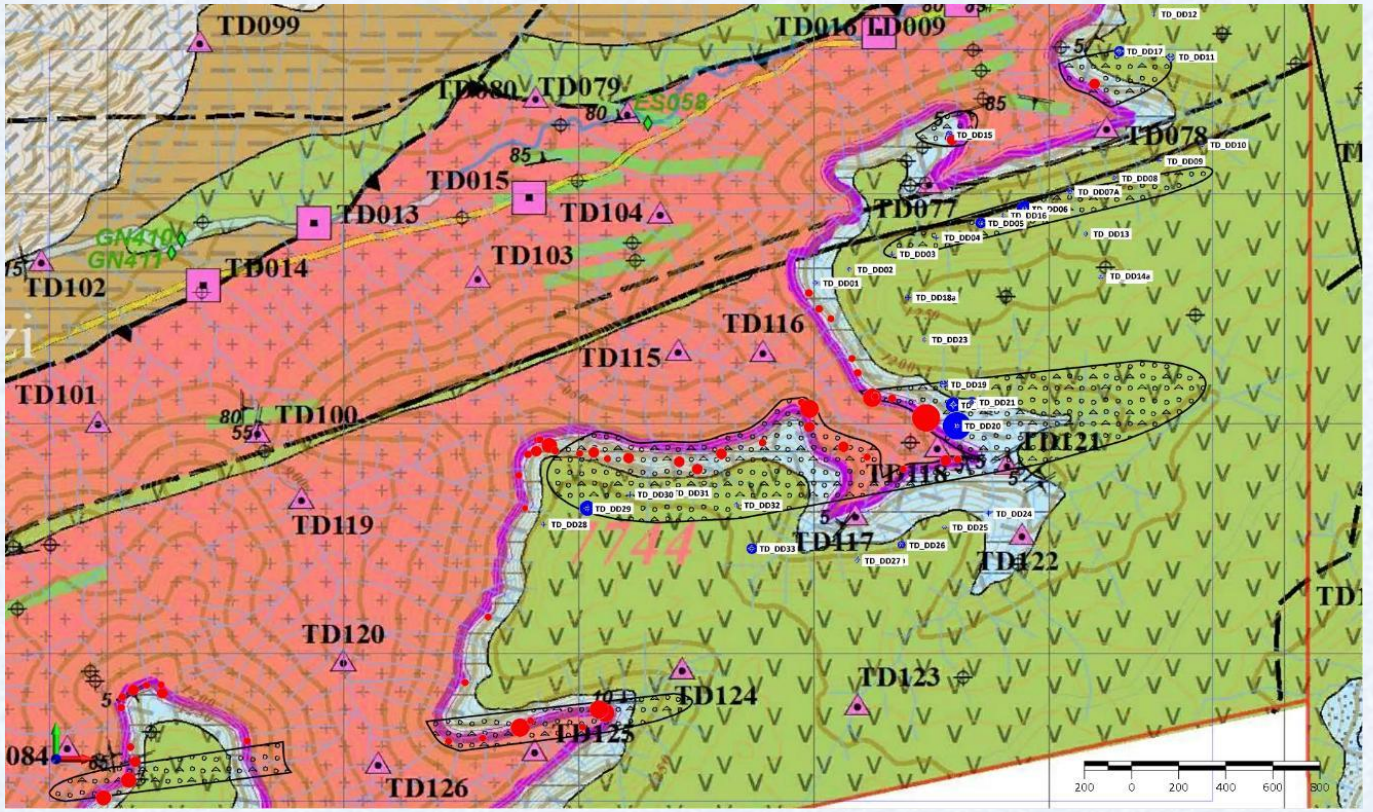


Fig. 10. Geological map with results of the drilling operations.

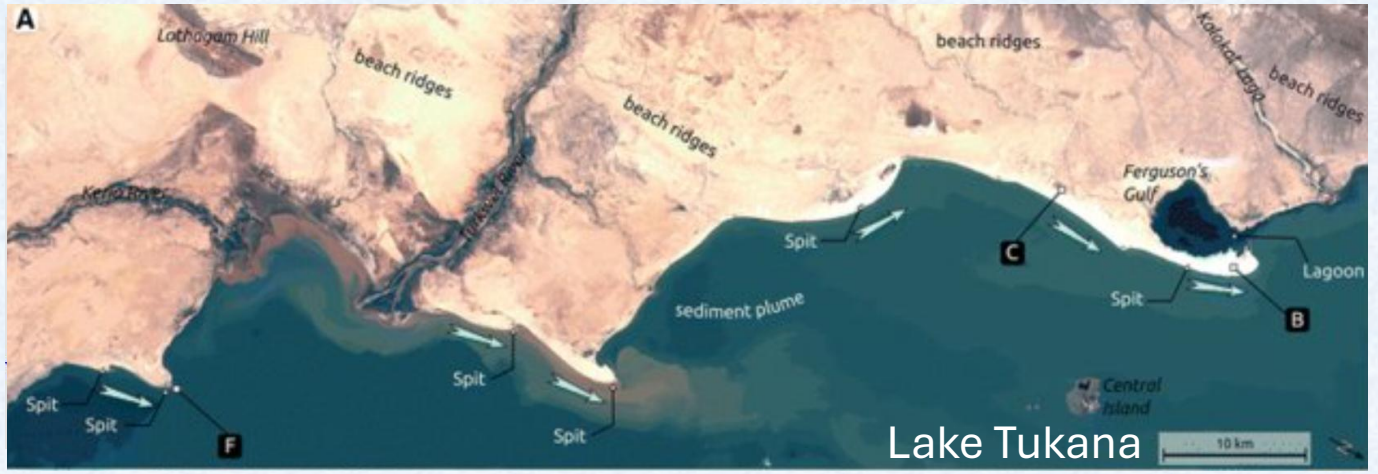


Fig. 11. The cross section along the drilling line.

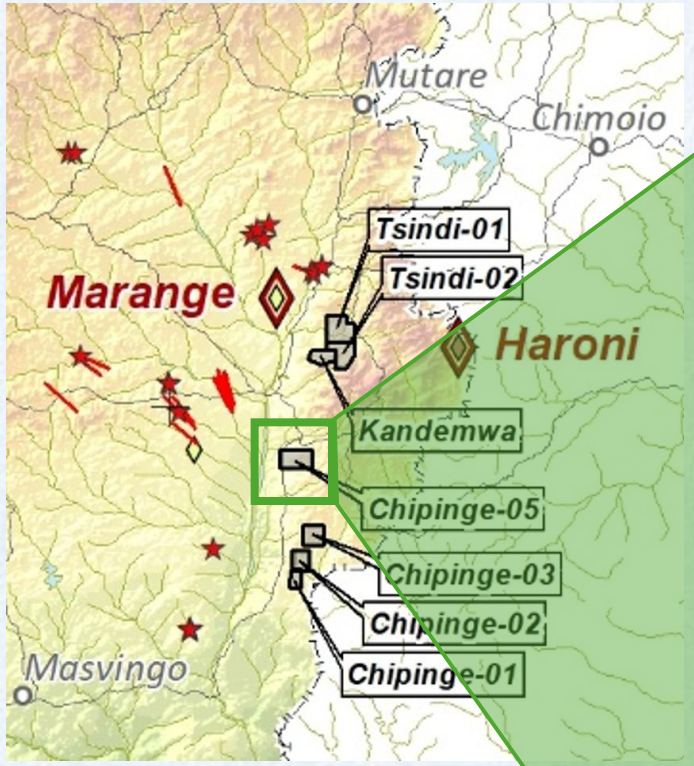


Fig. 12. Drilling rig at the work site.

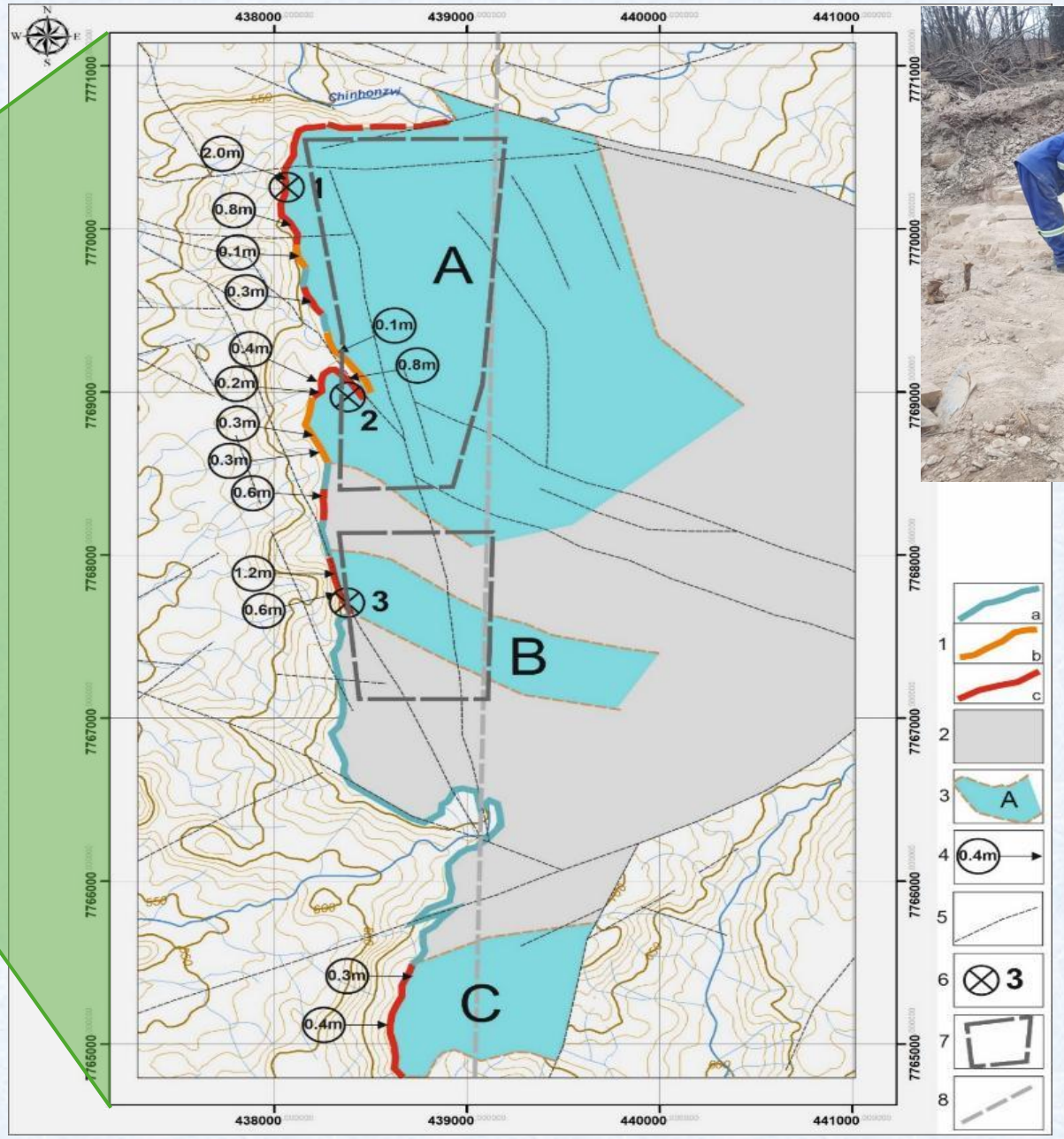
BULK SAMPLING, CHIPINGE AREA

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BULK SAMPLING



Fig. 10. Exploration plant at the Shinje camp including the department of the final diamond recovery.

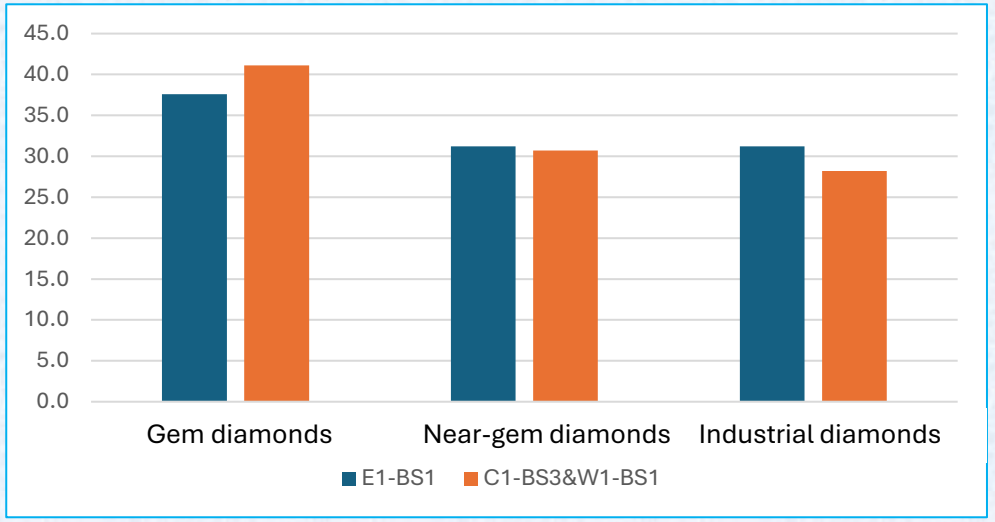


Fig. 12. Ratio of quality characteristics of diamonds from samples E1-BS1 and C1-BS3 (%).

Fig. 11. Weight of bulk samples collected from the Umkondo conglomerates and sampling results.

Sample ID	Bulk sample, tons	Area	Diamonds recovered	Weight, ct	ct/m3
C1-BS3	328,2	Tsindi	715	152,08	2,03
E1-BS1	92,22	Tsindi	191	59,88	3,09
CG5-BS/2,6	43,1	Chipinge	2	0,06	-

DIAMONDS CHARASTERISTICS

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- Diamonds from all deposits are characterized by the presence of traces of mechanical abrasion.
- In addition, the vast majority of the diamonds (around 70%) exhibit brown pigmentation (ranging from isolated spots to large areas of intense surface coloration), giving large diamond lots an overall brownish colour, often with varying shades of grey.

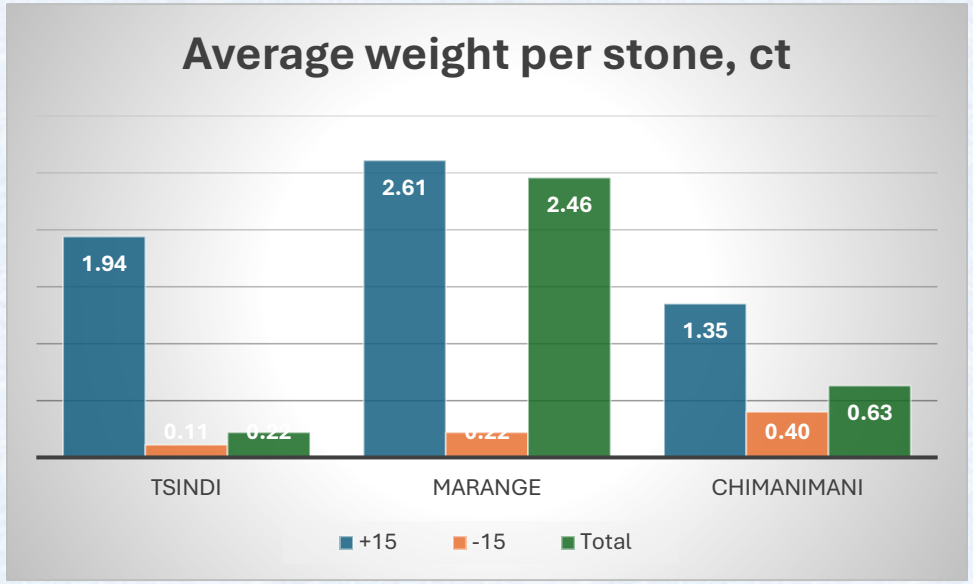


Fig. 13-16. Photographs of diamonds from bulk samples taken at the Tsindi sampling site.

Fig. 17. Diagram showing the average stone weight by size class for the Marange and Chimanimani placers and the Tsindi site.

Note:
1.The diamond population was separated based on the nominal +15 sieve class (lower limit of +4 grains and above);
2.The average diamond weight was calculated using the lower limit of the +3 size-weight group (+1.18 mm);
3.Diamonds in the "Boart" category were excluded from the calculation.









Source of the diamonds	Charasteristics
Marange	The proportion of whole crystals in the lot does not exceed 10%. Among them, diamonds of transitional forms, specifically octahedron-rhombododecahedron, predominate. The color of the diamonds is brown and yellow-brown.
Tsindi	Featureless diamonds (the habit cannot be determined due to the absence of natural crystal faces) account for more than 51%. The remainder is identified as fragments of octahedral habit diamonds exhibiting various crystallo-morphological features on the {111} surfaces. More than two-thirds of the individuals are colorless or have a slight yellowish tint. Polycentric growth faces of diamonds – 17% of identified habit diamonds.
Chimanimani	Diamonds occur as well-formed crystals of octahedral habit (55%) and, much less frequently (1–2%), rhombododecahedral habit. The remainder consists of featureless diamonds. On fresh cleavages of the individuals, the diamonds are colorless or have a slight yellowish tint.

MINERALOGICAL SAMPLING

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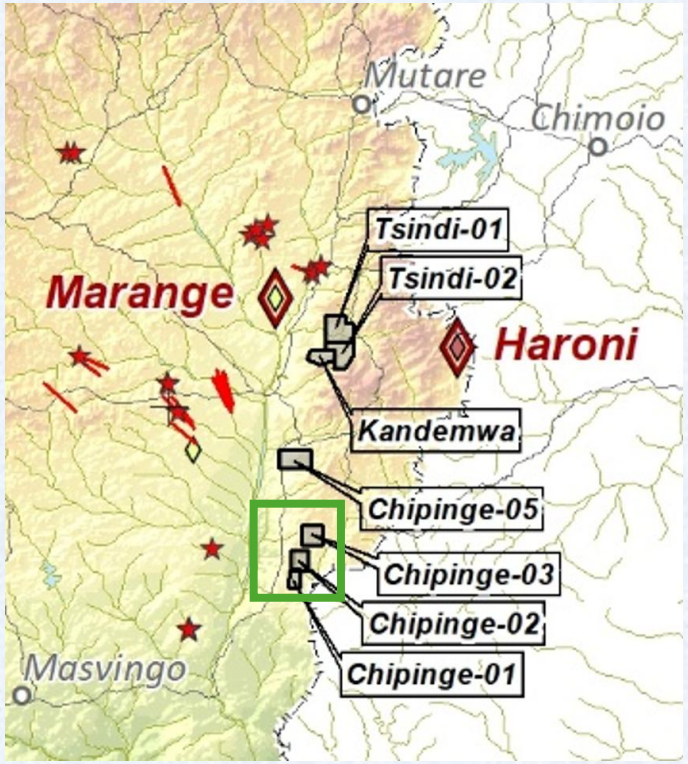


Fig. 18. The locations of exploration sites







Fig. 19-21. During the loam sampling program, the company was using a full cycle of loam samples processing based on its own facilities (field camp and BYO office).

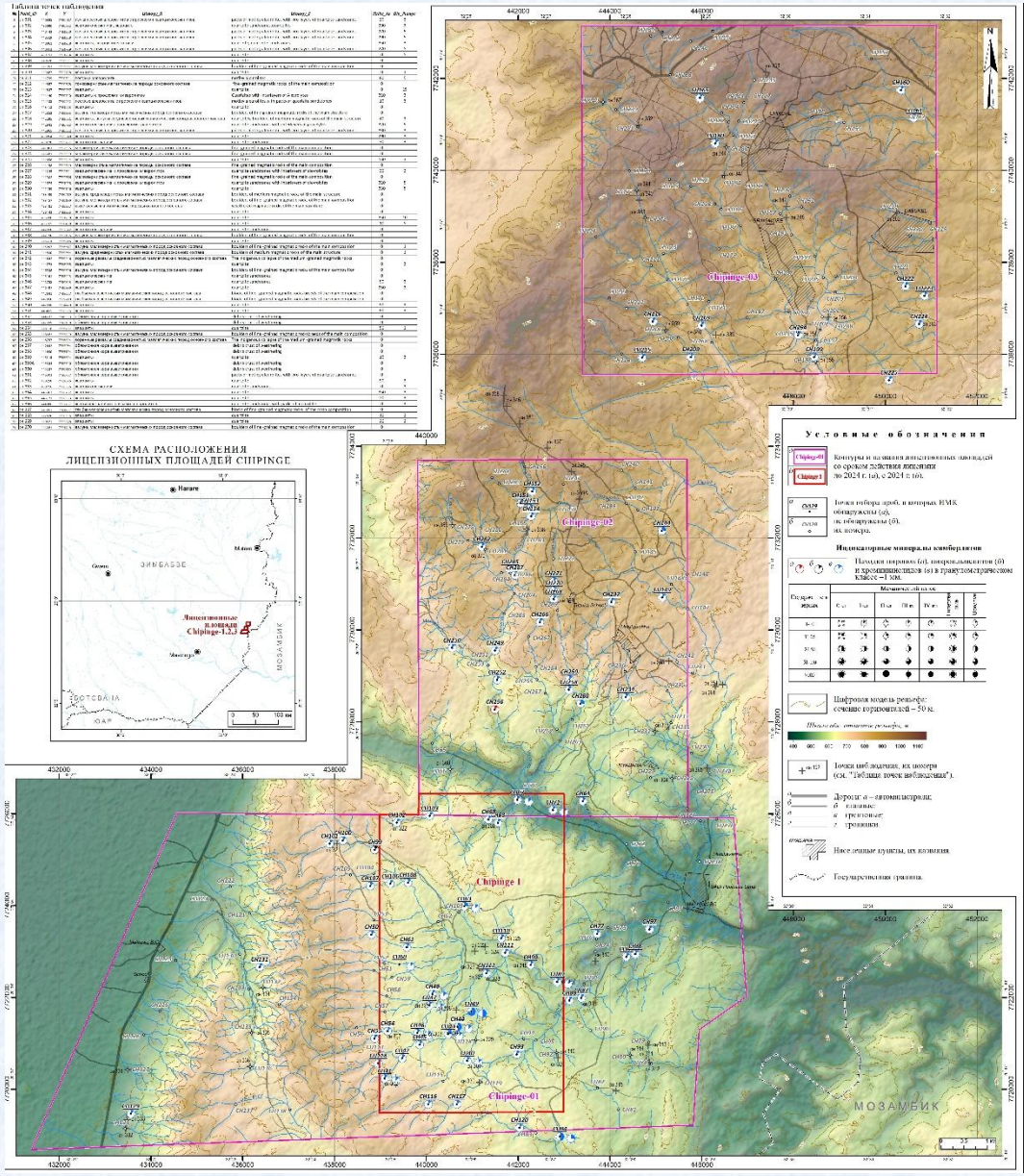


Fig. 22. Map of mineralogical sampling results

MINERALS CHARASTERISTICS, CHIPINGE

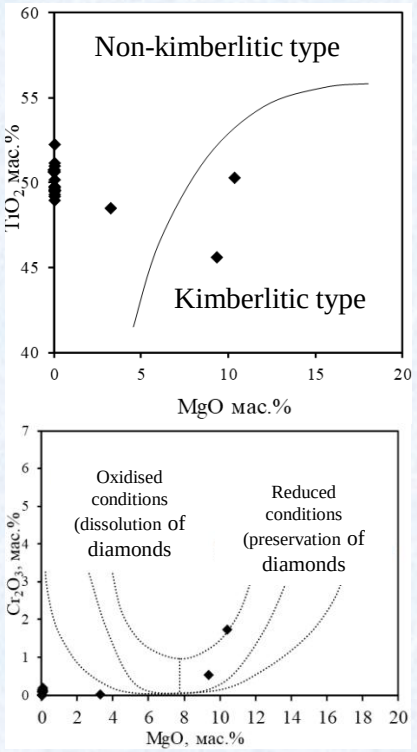
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Mineralogical sampling of alluvial sediments, followed by Geochemical investigation of the recovered minerals, also identified several mineralogical anomalies represented predominantly by chromites and picroilmenites.



Fig. 23. Kimberlite indicator minerals from heavy mineral concentrates collected in the Chipinge license areas. Picroilmenites (a, b) and chrome spinels (c, d) from the Chipinge 4 (a, b, c) and Chipinge 1 (d) sites; wear class 0–I, -1.0/+0.5 mm fraction.



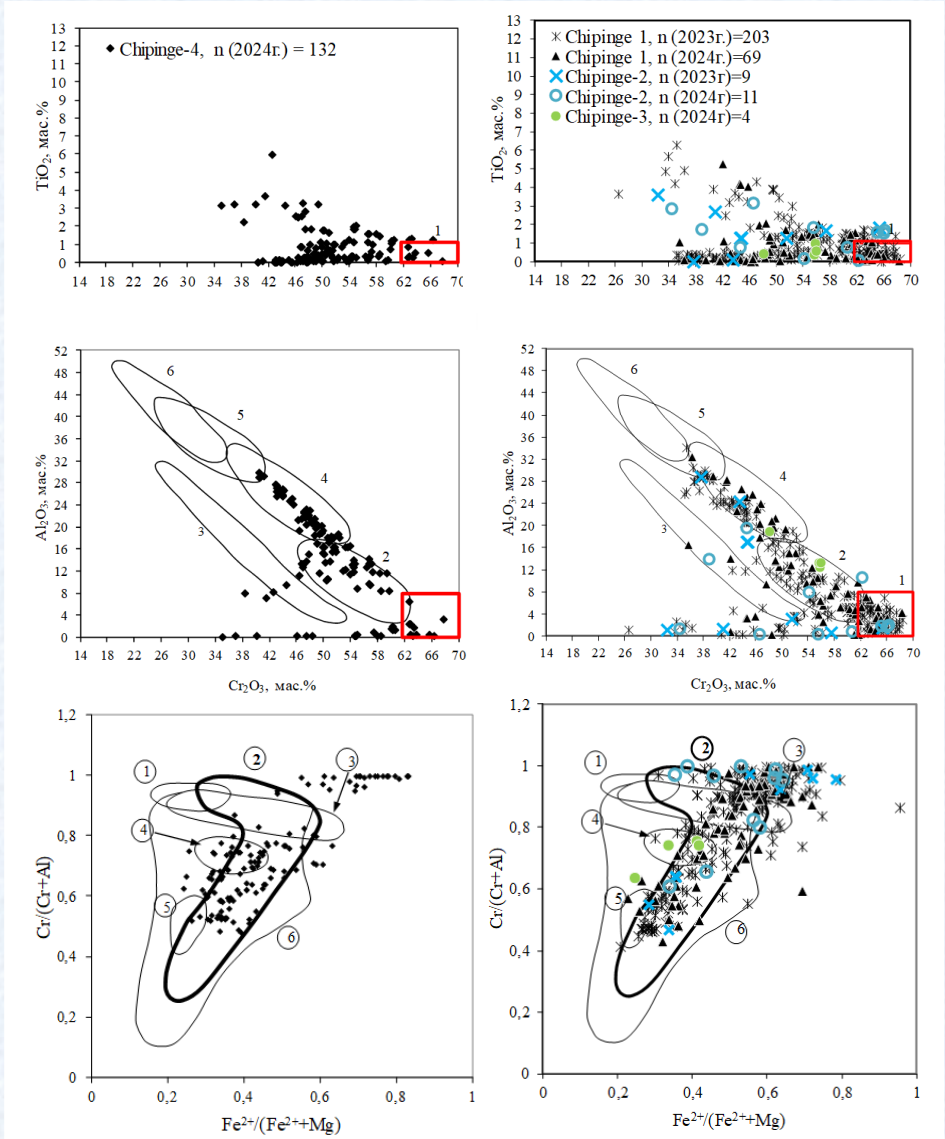


Fig. 24. Compositional characteristics of ilmenites from the Chipinge-4 area. On the diagrams: a – I.P. Ilupin; b – A.E. Moore and D. Schulze, with the S. Haggerty parabola [Moore, 1987; Schulze et al., 1995];

Fig. 25. Compositional characteristics of chromites from the Chipinge-4 areas Diagrams: a,b – N.V. Sobolev [Sobolev, 1974], c – R.H. Mitchell [Mitchell, 1986]

Fig. 26. Compositional characteristics of chromites from the Chipinge-1,2,3 areas Diagrams: a,b – N.V. Sobolev [Sobolev, 1974], c – R.H. Mitchell [Mitchell, 1986]

THE RESULTS

As a results of our prospecting works:

- **We have discovered diamonds at our bulk sampling sites (Tsindi and Chipinge);**
- **We have discovered kimberlite trace minerals in Chipinge area;**

But we still did not answer on the questions:

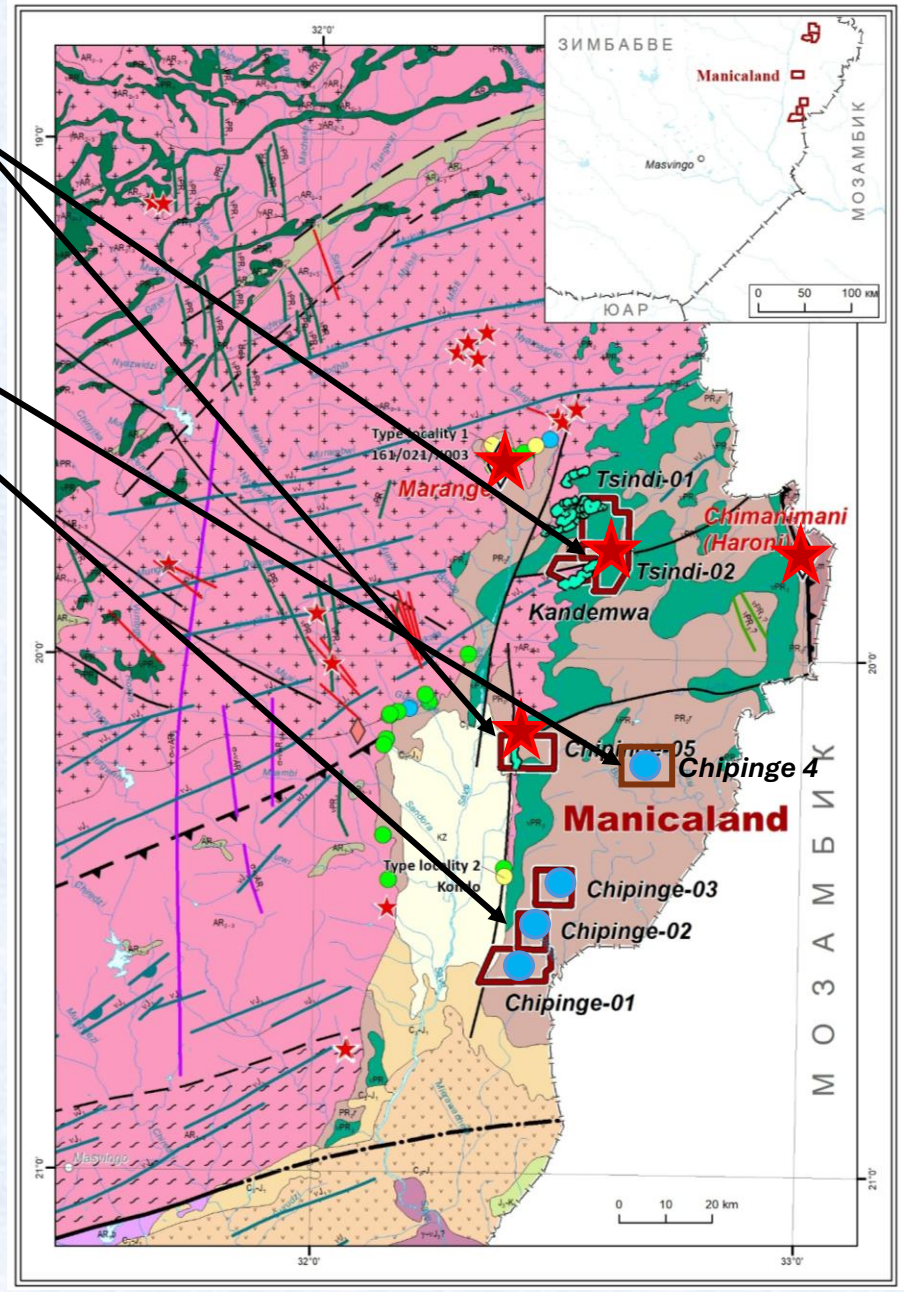
- ***What are the parent rocks for those diamonds?***
- ***Are the kimberlite indicator minerals related to these diamonds?***

There is a numerous of known kimberlites around the Marange deposits, as well as kimberlites trace minerals (basically ilmenites and spinels, and pyropes).

- Before, 35 kimberlites have been discovered in Eastern Zimbabwe, of these 17 are pipes, and the rest are dykes, sills or blows.

Could these kimberlites be the sources of the diamonds of the Proterozoic Umkondo placers?

- Most of the known kimberlites within the Zimbabwe Craton are too young in age (502-538 Ma).
- Mwenezi kimberlite event (1.15 Ga) - most probably still too young to produce Marange-scale diamond placers.
- The kimberlites in eastern Zimbabwe have not yet been dated.



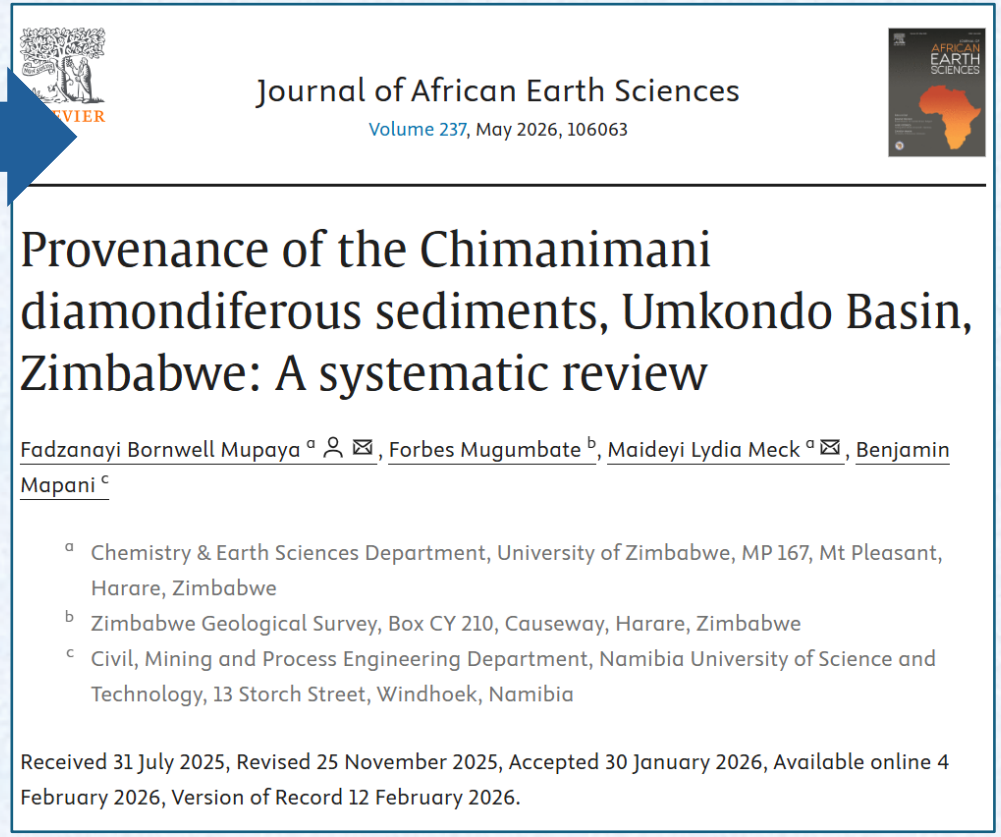
THE RESULTS

- It can be stated that ancient diamond placers are more widely distributed within the Umkondo Basin and, in most cases, are buried beneath a thick sequence of sedimentary rocks and dolerite sills.
- The results obtained demonstrate a pronounced spatial heterogeneity in the distribution of Kimberlite minerals within the Save basin. The most contrasting associations are concentrated at Chipinge-1 and Chipinge-4 areas.
- Based on the chemical composition of the discovered minerals, we can confidently state that the minerals are of mantle origin.
- The picroilmenites composition are indicating a kimberlitic or related to kimberlite genesis.
- Furthermore, the minerals' pristine surfaces—showing no signs of mechanical abrasion —suggest the possibility of relatively short transport distances;
- Regarding the studied kimberlite indicator minerals, we cannot establish a link to Marange/Chimanimani-type diamonds.

There are two possible sources of the indicator minerals:

(1) direct input from local primary bodies related to kimberlitic or related magmatism, and

(2) secondary liberation of KIMs through the erosion of sedimentary collector.



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Provenance of the Chimanimani diamondiferous sediments, Umkondo Basin, Zimbabwe: A systematic review

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MARANGE/CHIMANIMANI AREA DIAMONDS CHARASTERISTICS

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What we know about Marange diamonds? To understand the genesis of diamonds, it is important to study the diamonds themselves, as they carry significant information that helps answer certain questions.

- Macrocrysts are octahedral but tend towards spherical shapes;
- Outer surfaces are extensively abraded with abundant percussion scars;
- Green and brown surficial staining is common on macrocrysts;
- Coupled green and brown radiation spots on abraded and fragmented surfaces;
- Macrocrysts are often broken and/or fractured with fresh unabraded fracture surfaces;



All these characteristics are non-genetic (primary genesis); rather, they point to a complex and prolonged history of the diamonds residing in the external environment following the emplacement of the host rock.



MARANGE AREA DIAMONDS CHARASTERISTICS

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The genetic features (K.V. Smit et al. / Lithos 265 (2016) 68–81**):**

Features	Marange Diamonds	Explanation
Spectral absorption features and nitrogen aggregation (A/B centres).	High **971–2628 (**ppm) total nitrogen contents, Low (<40%) nitrogen in the B form;	Relatively short residence time at high mantle temperatures
$\delta^{13}C$ range	A relatively narrow $\delta^{13}C$ range, around **−8.5‰;**	Such values are compatible with mantle carbon, including carbon that has undergone isotopic fractionation or has been modified by recycled carbon-bearing material.
Inclusions	Cuboid growth sectors containing abundant methane (CH4) microinclusions associated with graphite.	Accordingly, any reduced CH_4 flux originates from within the oceanic crust, likely through serpentinisation, whereas any mantle-derived carbon-bearing gases are mostly CO_2-rich.
Mixed-habit	Cubo-octahedral syngenetic growth	While cubic diamonds are rare in classic global deposits (typically accounting for only a few percent of the total mass), the Marange diamond population is almost entirely characterized by cubo-octahedral syngenetic growth, with cubic sectors dominating the internal volume of the stones.
$\delta^{15}N$ range	Modelled source-fluid $\delta^{15}N$ values of approximately +2.3 to +6.4**‰;**	Evidence for a recycled metasedimentary component, potentially introduced through subduction of eclogitic oceanic crust.

Detailed source composition modelling shows that these diamonds grew from mixed CH_4 to CO_2 fluids derived from oceanic crust that was subducted and emplaced into the Zimbabwe cratonic lithosphere.

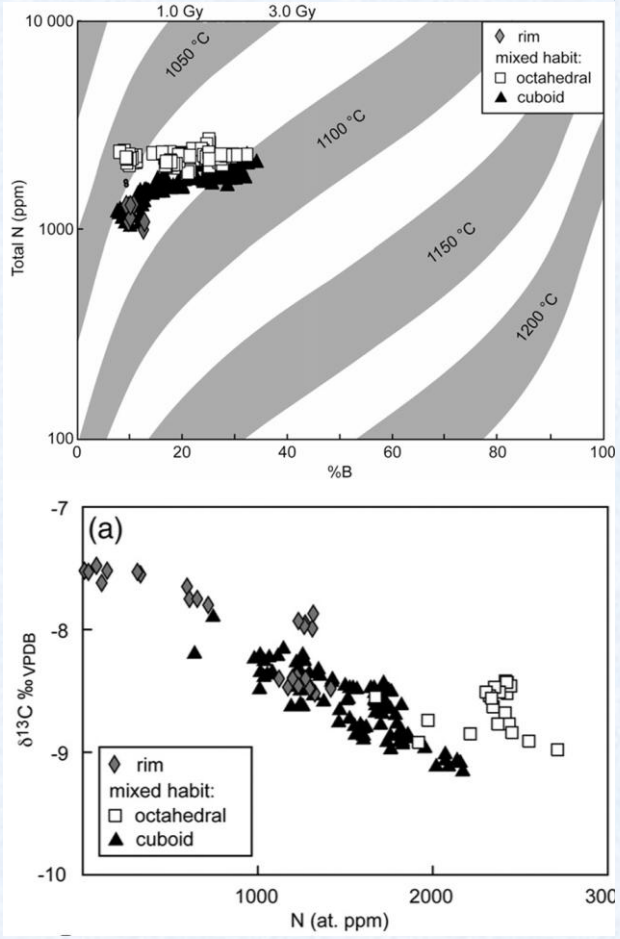
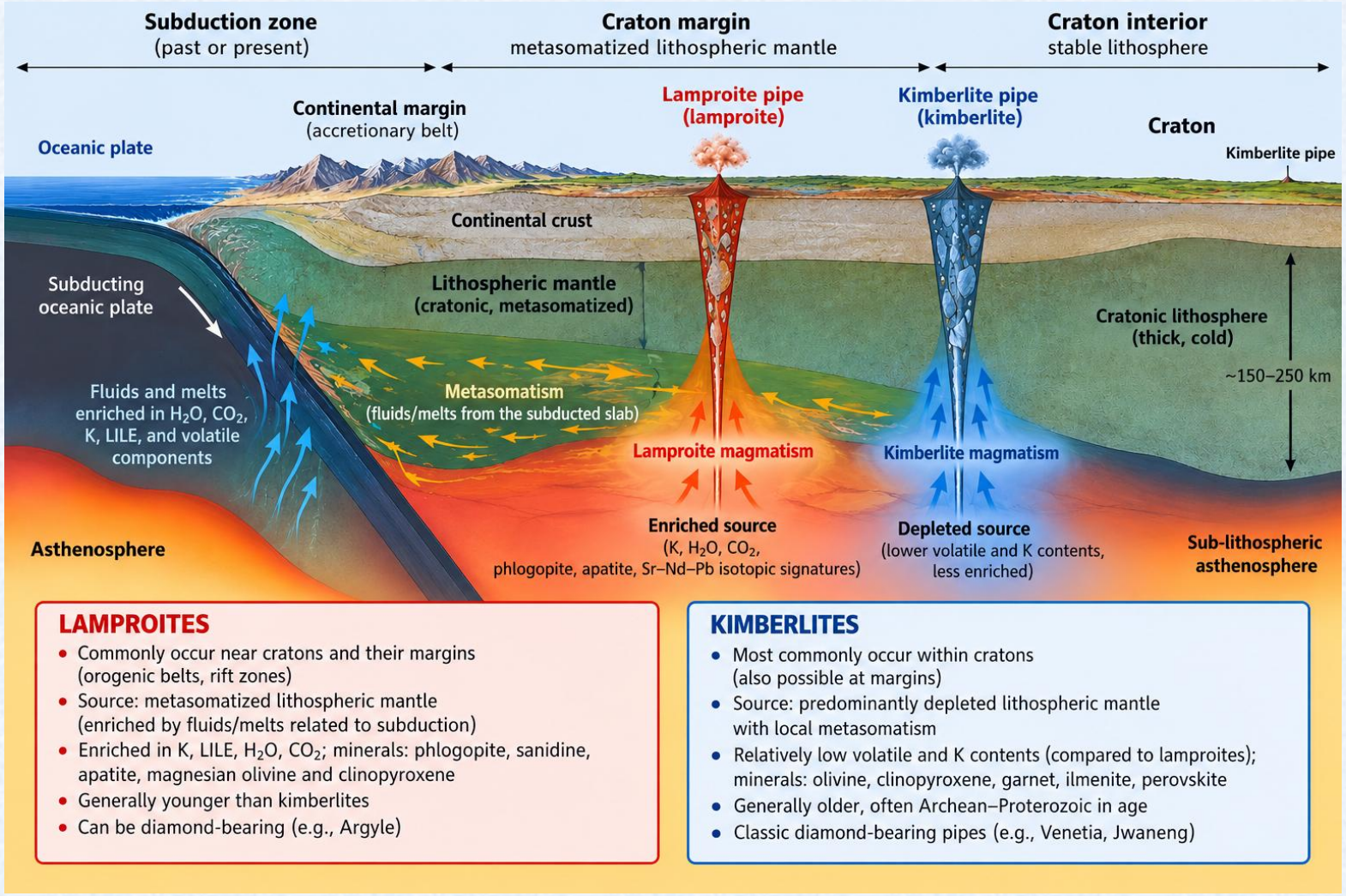


Fig. Nitrogen content (logscale) plotted against the percentage of B aggregation (100B/ [A + B]) for thirteen Marange diamonds.
Fig. δ13C and N content co-variations in four Marange diamonds.
K.V. Smit et al. / Lithos 265 (2016) 68–81

Thus, we can summarize...

- The diamond finds from the ancient Umkondo Group sediments show that, while the diamonds exhibit varying granulometry characteristics, but they share the same features indicative of their ancient nature, pointing to a unified formation history within the Umkondo Basin.
- Studies of the diamonds (morphology, nitrogen aggregation state, carbon and nitrogen isotopic composition, fluid micro-inclusions) indicate that the observed characteristics point to a non-kimberlitic origin.
- Detailed source composition modelling shows that these diamonds grew from mixed CH4 to CO2 fluids derived from oceanic crust that was subducted and emplaced into the Zimbabwe cratonic lithosphere.
- **In other words, the parent rocks could be located closer to the margin of the craton—towards the convergence zone, i.e. the Mozambique Belt or the Limpopo Belt.**
- **Lamproites is a good example for such parent rocks for Marange diamonds, given their confirmed presence in the region (for example, the Save 9 pipe) and correspond to all described above genetic features of the diamonds.**



Thank you for attention!