Regolith Mapping-the key to successful mineral exploration

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Ghana
What we did not Understand

Failure to understand **Regolith environments in different climatic areas**

Assumption that **regolith is the same everywhere**

Using the same **Exploration strategies** irrespective of **regolith terrains**

Significant decline in **exploration success**
Fate of Mineral Industry & Our Position

GOLD is an Asset but considered a depleted NATURAL RESOURCES - Non Renewable

Less DISCOVERY more PRODUCTION (2001-2007)

SUSTAINABILITY of Mineral Industry NOT SAFE

Your POSITION not SECURED with this trend

Australia, Africa and Brazil have most areas characterized by DEEP REGOLITH.

This makes us vulnerable if we cannot factor regolith changes during geochemical data interpretation.

Source: Ravi Anand - CSIRO
CSIRO has done a lot of Regolith Research in Australia.

Many deposits have been discovered under cover when the understanding of the regolith was realised.

Their Regolith Research Strategies were therefore borrowed for Northern Ghana.

WHAT DID WE LEARN FROM THAT?

“Significance of **Regolith Mapping** for successful Gold Exploration in Northern Ghana”
What we know and the missing link

Assumed **ALL regolith are the SAME.**
Determined **Anomalies** from Surface Samples-
Conventional Method.
Since time Immemorial to Date

- **PAST**
  - How Did We Get Here?

- **PRESENT**
  - Where Are We Now?
    - Exploration in **Heterogeneous regolith.**
      - Still interpreting geochemical data **ignoring** changes in **regolith unit.**

- **FUTURE**
  - Where Do We Go From Here?
    - Create **Regolith Map.**
      - Interpret Surface Geochemistry with the **Regolith Map.**
      - You have the **Prospective Targets NOW.**
1. What should WE do? – More questions for us

2. Do we continue with the past conventional exploration methods?

DECLINING TREND REVERSAL IS NECESSARY!!!!!!

3. What can we do?

THINK ABOUT THESE!!!

4. WHAT DO YOU THINK WILL BE THE FUTURE OF MINERAL INDUSTRY
My VIEW!!

Check PAST exploration methods

Assess the PRESENT exploration strategies

Design FUTURE exploration strategies
Future exploration programs should incorporate regolith studies

What is the point?

In the PAST
Geochemical samples were taken from:

1. Outcrop and partial truncated areas

So Conventional exploration methods were successful
Present exploration is conducted in......

Homogeneous and Heterogeneous regolith areas

Conventional exploration method is 50/50

- Relict materials
- Ferruginous materials
- Depositional materials
The regolith regimes are linked so are the geochemical expressions...

• The Reason:
  – landscape features adjust to changes in the process, forming a cause and effect relationship to maintain static equilibrium.

• Therefore identifying anomaly-types from different regolith require **REGOLITH STUDIES**
Anand classified the landscape into “RED”
RED

Classifies the regolith-landform into

Relict (R)
Depositional (D)
Erosional (E)

Anand and Smith (1993)
**RED** concept is a simplification BUT it works

**E.g. Relict regime** do not form a widespread, continuous unit on peneplain surface but

Forms a discontinuous cover on a broadly undulating terrain

The relict materials undergo several cycles of weathering and erosion so there are some

That can be considered as semi residual.
Anand and Team

• Included lateritic residuum (residual lateritic duricrust and lateritic gravel) in Relict regime

• They also characterised ferricrete (ferruginized sediments) in Depositional regime
But in northern Ghana

• The several exploration failures demanded mapping the laterite units onto a different layer

• So that their impact on geochemical dispersion in the complex regolith can be
  – acknowledged
  – Used to devise suitable exploration methods
This resulted in a slight departure from RED TO FRED.

From geochemical exploration perspective, weathering causes the destruction of primary ore deposits and the dispersion of ore and pathfinder elements in the surrounding regolith.

Lateritization may result in element-coating to affect elements mobility and dispersion.

Laterites are effective geochemical sampling media, because they can scavenge and concentrate ore-related elements and have contributed to the discovery of many gold and VMS deposits in Australia and elsewhere.
The focus on “F”

Is to distinguish between:

Lateritic residuum/duricrust or residual laterite and Ferricrete or transported laterite

Lateritic residuum develops from bedrock by residual weathering processes.

Ferricrete develops by conglomeration of clasts and sand of distal origin and impregnation by goethite.

Ferricretes have little relationship to the underlying rocks (Anand, 2001).
Reason for the departure—hope it’s necessary

- There are many types of laterites

- Their relationship to mineralisation and bedrock vary quite considerably,

- Their suitability and use for exploration depends on environments under which they form.

- So it is important to understand the differences and make distinction between genetically different types of laterites.

- Exploration success depends upon the use of the appropriate material.
NOW LET’S GO TO SAVANNAH REGION OF NORTHERN GHANA

SIGNIFICANCE OF REGOLITH MAPPING
Regolith landscape Model for Lawra area and why Regolith Mapping is Significant
What can We Gather from the Model

1. There was Weathering (It causes destruction of ore deposits and the dispersion of ore pathfinder elements)
2. Erosive process occurred along the line (Resulting in Geomorphological changes)
3. Redistribution of weathered products at some places (Transportation of materials)
4. Transformation of primary minerals to secondary minerals (Lateritization process)
5. Evolution of Regolith and Landscape (Distorting geochemical patterns)
Geochemical element appearance in Surface Samples

Less complex regolith characterise humid tropical environments e.g. Rainforest of Ghana—mineralisation and dispersion style

Detrital Au mechanically transported

Displaced Au anomaly

Erosional regime  Relict regime  Depositional regime  Ferruginous regime

Gold expressions in the surface geochemistry in the study area encompasses the four modes of Au mobility and dispersion patterns displayed above; a characteristic geochemical patterns of complex regolith environments of savannah of West Africa

Ore body  Dispersion halo  Residual soil  Laterite

Mottled clay zone  Saprolith—sap rock & saprolite
EFFECT

Evolving Regolith-landform units will affect:
1. Geochemical element Dispersions
2. Make surface geochemical data interpretation CHALLENGING
3. Miss potential anomalies whilst
4. Following ‘FALSE’ assays
Coating of gold by Fe-oxides and clay minerals

Gold grains can be coated by Fe-oxides during laterite formation.

Steps: Add gold to the quartz float, 2. Create coating using tan red colour around the quartz and gold. 3. This method should be repetitive to explain how gold grains are coated during laterite formation. This occurs in both in situ and transported laterites.
In situ laterite

Continuous dispersion of gold from the bottom upwards. Spread of gold should be broader at surface and thinner at depth. E.g. Solid at base and broken lines as you get to surface to show continuity in path but variations in value.
Transported laterite or ferricrete: Fe oxide-cemented colluvial and alluvial sediments

Random distribution of Gold. Design so that gold is injected into this laterite in a disorderly manner. Use golden colour for gold and it should be mobilised from the bottom. Animate in such a way that audience will know source gold can come from any direction and from many materials.
Location and Regional Geology

The map illustrates the geology of a region, with different geological formations and rock types color-coded. Key features include:

- **Post-Eburnean Domain**: Neoproterozoic/Phanerozoic rocks
- **Eburnean Orogenic Domain**:
  - Granitoid rocks
  - Tarkwaian sedimentary rocks
  - Birimian sedimentary rocks
  - Birimian volcanic rocks
- **Archean Terrains**:
  - Pre-Birimian basement rocks
  - Gold deposit
  - Towns

Geographic regions include:
- Senegal
- Mali
- Burkina Faso
- Benin
- Ghana
- Côte d'Ivoire
- Guinea
- Sierra Leone
- Liberia

The map highlights the distribution of these geological features across the region.
Local Geology

**Typical Greenstone belt:**
Metavolcanic and Metasedimentary rocks

Intruded by intermediate and mafic granitoids

The rigid intrusive bodies result in brittle and ductile deformation.

Pathways and emplacement zones result afterwards.

Geology, structural deformational styles are similar to Ashanti belt **BUT** there is no Productive mines in the area.

We can only report about **gold occurrences and prospects** in the area.
Regolith-mosaic of landscape features: disorderly distributed
The Regolith.....

The rapid landscape changes during weathering, erosion, transportation, deposition and lateritization have implications for geochemical gold exploration.

The changes can enhance local re-distribution of surface regolith materials that may cause surface geochemical expressions to be misleading.

Mixed geochemical patterns of high, weak, subtle and discontinuous signals result. Interpretation cannot be effective if the regolith environment is not understood.
Gold is Everywhere—where do you start from?

- Different geochemical patterns
- Generally disfigured
- Some linear
- Others spotty
Slide 31 suggests gold mineralisation in the area. But some are real others are false.

Archival reports confirmed discrepancies in results at grass root exploration stages. Many of the red spots: returned insignificant and generally weaker Au assays from sub-surface regolith samples.

(Griffis et al. (2002); Ashanti-AGEM Alliance internal report-Carter, 1997-unpublished).
How do we distinguish REAL from FALSE anomalies

• This is Proven and Tested:
• Delineation of anomalies from surface soil Au geochemical data needs:
  – the application of regolith map over geochemical grid map
    • to distinguish residual anomalies from the transported or false anomalies.
Gold anomalies were interpreted with respect to regolith type.

Geochemical targets were defined by assessing the nature of Au anomalies in different regolith domains.

The Au-rich and Au-poor regolith materials irregularly distributed on the landscape were distinguished by map superimposition.

In this case: drape of geochemical circle plot on regolith map matching Au assays with regolith types was carried out.
A. Ferruginous regime disregarding effects of regolith; B. Accounting for regolith type
Ferruginized regime (F)

- Patchy, subtle and isolated anomalous areas portrayed
- This could be due to the encrustation of fine detrital gold.
- May mask potential mineralisation in surface samples.

- Constraining anomaly w.r.t to regolith in B may be useful to test for hidden anomalies at the early stages of the exploration.
- But we may have to think about the sample preparation methods.
- Inappropriate preparation process may result in only a fraction of Au content to be analysed.
- This may result in low assay values in lateritized terrains
A. Relict regime disregarding effects of regolith; B. Accounting for regolith type
Relict regime

- The high Au areas >500 ppb in this regolith regime appear patchy and small in size

- Exhibit spot-high-discontinuous anomalies and reflect the patchy occurrence of the relict regimes

- These types of anomalies based on size alone may not merit further exploration survey

- Anomaly definition accounting for regolith effects in the right figure shows continuous anomalous size.

- That may merit follow up surveys than the spot-high anomalies shown in the left figure.
A. Erosional regime disregarding effects of regolith; B. Accounting for regolith type
Erosional regime

- Non-contiguous spot-high Au anomaly-patterns.

- Use of high Au assay values as threshold will mark the area as uneconomic and result in exploration survey termination.

- Potentially missing anomalies via sediments covering relict and erosional surfaces

HOWEVER

- The regolith mapping provided an immediate answer for this area and

- **Suggested the dominance of the flood plain of the Black Volta River to cover most low-lying areas diluting the anomaly potential.**
A. Depositional regime disregarding effects of regolith; B. Accounting for regolith type
Depositional regime

- Variable gold distributions with several spot-high anomalies

- These anomalies are surrounded by background assays

- Could be due to the evolution of the regolith transforming the original homogeneous regolith to complex heterogeneous regolith.

- Many of the several discontinuous anomalies may be unrelated to bedrock mineralisation
A). Merged Au anomalies in different “FRED” regolith domains
B). Definition of anomalies regarding regolith implications on Au mobility in surface regolith.
What we miss if.................

• Anomalies in ferruginous and depositional areas may be overlooked.

• Some high Au assay areas may not relate to bedrock mineralisation (False anomalies)

• Some low assay areas may be influenced by Au-poor sediments causing anomaly-dilution

• Threshold selection may be very challenging and may lead to missing potential hidden anomalies
Sure way!!!!

- Independent classifications of anomalies in the various regolith regimes will address the problem of following false anomalies.

- The principle in this approach is given anomalies in each regolith regime equal chance of hosting mineralisation and

- It works by incorporating the implications of regolith on element dispersions and concentrations.
Getting There

Elimination of traditional use of single high threshold values

Anomalies in ferruginous and especially depositional regimes will not be overshadowed by high thresholds set from erosional and relict regolith.
Where is the advantage

The approach of defining anomalies independently in different regolith regimes before merging the individual anomalies as one showed the prospectivity of Au mineralisation (Slide 38)
Historical Exploration surveys in Lawra Birimian belt of Ghana

- In 1937 formal report of Au occurrence was made known in northern Ghana (Junner, 1937).

- Long before that, the local people engaged in artisanal mining activity, locally known as ‘galamsey’ (Griffis et al. 2002, Kesse 1985).

- Companies such as BHP Minerals, Ashanti-AGEM Alliance and many others explored for Au between 1960-1998 but were not successful - **Regolith studies were not incorporated**.

- My 2005 research on the “significance of regolith” indicated the prospectivity of the area.

- In 2006 Azumah Resources Ltd. took over the exploration licences in the Lawra belt.

- They incorporated regolith studies and were part sponsors of my PhD.

- Currently have found close to 2 Moz Au in a complex regolith environments.
Conclusion

• Regolith mapping is essential at ALL stages of exploration

• For successful exploration surface geochemical data must be considered separately with respect to different regolith regimes.
Why!!!!

• ..... high Au assays do not imply mineralisation.
• ..... high Au assays can be displaced through detrital dispersion.
• ......potential mineralisation can be masked by transported Au-poor sediments.

• Note **All** these are products of regolith-landform evolution processes.

• Can only be **captured** and **used** when mapped at an appropriate scale
What are we taking home

• To really define realistic anomalies that relate to mineralisation:
  – Equal weights of importance must be accorded to anomalies defined in the different regimes.
  – No single threshold value must be used as it often overlooks the subtle anomalies at low concentration Au areas.
  – Prioritization of anomalies for follow up.
  – The understanding of the regolith environment via regolith map is key to the proper interpretation of geochemical data for geochemical surface target generation.
  – We can delineate Au mineralisation in areas under cover now.
Sustainability Success

SPEND LESS in Exploration

SAVE MORE for new areas

MORE BUDGET FOR SUCCESSFUL EXPLORATION THAT ACCOUNTS FOR REGOLITH CONSTRAINTS

USE REGOLITH MAPS, FIND HIDDEN ANOMALIES, MORE DISCOVERIES

SUSTAINABLE FUTURE FOR MINERAL INDUSTRY
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AVAILABLE FOR CONSULTATION ANYTIME
End of Talk

THANK YOU