Geological Society of Zimbabwe

Newsletter

February 2013

A Group Photograph taken during the Geological Society visit to Marange Resources Diamond Workings, December 2012
PHOTO: per Daniel Chatora

The Geological Society of Zimbabwe, P.O. Box CY 1719, Causeway, Harare

Contents

Editorial

Thanks, as always are due to our faithful contributors, who make this Newsletter worthwhile.

News has been received concerning the passing of two of our fraternity – **Archibald Patsanza** and **Albert Vembo**. Whilst recording our collective condolences to families and friends, the Society will observe a moment of silence as a precursor to the AGM on Friday 1st March, when obituaries will be read. The latter will be published in our following Newsletter.

It follows that the AGM needs your participation. The AGM is scheduled for 5.30 pm at our usual venue, the CFX Academy Country Club, Brompton Road, Eastlea. This is always a good chance for us to interact with our friends and peers. See you there.

Tim Broderick

Chairperson's Chat

Fadzanai Bornwell Mupaya

A Happy 2013 and a prosperous New Year to you all.

This is my last communication to you as the Chairperson of the Geological Society of Zimbabwe for 2012. My term ends on the day of the AGM on 1st March 2013. Great thanks are due to the committee under my chairmanship for competently running the affairs of the Society as we emerge from the most difficult times of the recent past. All Members of the Society are acknowledged for the support they gave during my tenure of office. The support by various companies to Society activities through cash and other donations is gratefully recognized. Lastly but not least, I wish the new committee all the best.

The now popular Summer Symposium was held at the University of Zimbabwe on the 30th November 2012. Many thanks go to Andrew du Toit for making the 2012 Summer Symposium a most memorable event. The attendance was much more than we expected. The presentations were of top quality. We wish to extend our appreciation and thanks to all the presenters for finding time to prepare such informative papers. The author of the best paper will be presented with the Keith Viewing Award at the Annual General meeting to be held on the 1st March 2013.

In addition to the now traditional practice of inviting influential members of the industry to officially open the symposium, a keynote speaker of international repute was invited. The Symposium was followed by a most unforgettable field trip to the now famous diamond fields of the Umkondo basin. Daniel Chatora and I played a role in this. I would like to register my appreciation to the companies, Marange Resources and DTZ-OZGEO, that hosted the visiting geologists.

It is with sadness that mining activities, especially relating to minerals exploration, remain subdued despite government's promise to expedite the granting of exploration licenses. Much of the country is now open following the cancellation of hundreds of EPO applications.

However, the few applicants that showed interest have not yet been granted the EPO areas requested. The Geological Society is also concerned that the promised downward review of various mining fees has not been brought into practice.

Articles and Reports

Jock Harmer is the *Society of Economic Geologists'* "Travelling Lecturer" for Africa

Geological challenges in satisfying future global demand for the Rare Earth Elements

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REE are essential to many high technology applications: without REE, there would be no notebook or tablet computers, mobile phones, colour TVs or monitors; REE are used as catalysts in oil refining and are essential components of rechargeable batteries, lasers and optic fibres. But it is the magnetic properties of REE-metal alloys that have become the major demand driver in the 21st century. In 1985 most of the world's REE supply came from the Mountain Pass Mine in the USA but by 1998 China was producing more than 80% of world demand and now supplies over 95% of the world's REE.

In recent years China has implemented several long-term policy changes that have significantly impacted the amount of REE available for export. Consolidation of the Chinese REE industry from a large number of small producers to fewer, large integrated corporations that are easier to regulate has begun; illegal exports (smuggling) of REE have been reduced. At the same time, stricter controls have been implemented to address serious environmental impacts resulting from extraction and refining of the REE. China has also committed to stricter emission controls implementing several clean energy initiatives including increased domestic production of hybrid and electric motor vehicles and mopeds and the construction of wind energy farms (China spent $28 billion on wind energy in 2009). These applications use major quantities of Nd(Dy,Tb)FeB permanent magnets – a technology discovered in the early 1980's.

These policy changes have led to significant reduction of production along with increased domestic consumption of the REE. Export quotas have been implemented that reduced supplies of RE Oxides to non-Chinese consumers by 40% in 2010.

Significant non-Chinese REE production will start to enter the market in 2012/13 from the Mt Weld [1] and Mountain Pass [2] deposits, both operations producing predominantly LREE. Market projections show that demand for Eu, Tb, Dy and Y (all HREE) as well as Nd (a LREE) will remain higher than supply beyond 2015.

The demand for HREE poses a serious challenge to explorers. LREE are an order of magnitude more abundant in the crust than HREE and most geological REE enriching processes tend to enrich the LREE relative to the HREE. In addition to generally being of low grade, in many HREE-endowed deposits the HREE are hosted in mineral phases that are difficult (hence more expensive) to concentrate and/or dissolve requiring major capital outlay to generate a saleable product.

Advanced African, and non-Chinese, deposits were reviewed and their ability to satisfy future demand critically assessed.

A Summary of the November 2012 Summer Symposium

David Love

Today (30th November) is the annual conference of GSZ, and as usual there is an interesting mixture of industry and academic presentations. As has become the case in recent years, there were very few classical geology presentations, with academic papers mainly being on applied earth sciences like hydrogeology, environmental geology and geomedicine. Development of our understanding of Zimbabwean geology moves slower than it did in the 1990s!

In an overview from **Isaac Kwesu** of the Chamber of Mines, it was emphasized that apart from diamonds and platinum, our mines are operating well below capacity. Income in the sector was spent on imports and expenses, 15% wages, 17% taxes and royalties and 11% profits. Within the mining sector, gold, platinum and diamonds each contribute around a quarter of exports, against gold generating around half in the 1990s and platinum around half at the turn of the century.

Oliver Maponga spoke on the Zimbabwean coal industry and gave a fascinating overview of the history of Hwange Colliery. Lubimbi coal has excellent properties for conversion to petrol and diesel (like Sasol).

Sharad Master presented on the Magondi Supergroup, a classic geology paper with new SHRIMP geochronological data. The Lomagundi carbon isotope anomaly is now the type locality for this excursion worldwide and their paper has won the Phaup Award. The team, using funds they sourced on the basis of this award, have enabled re-dating of the Magondi using U-Pb SHRIMP. A maximum age for the Deweras volcanics – 2235 Ma; a Deweras clastics maximum age of 2171 Ma; a Lomagundi tuff – maximum 2070 Ma; the Godzi volcanics intruding the Piriwiri – maximum 2051 Ma; and that for the Nyagari volcanics being inconclusive. Older zircons show that the Zimbabwe Craton is basement to the Magondi Belt.

Master also reported on recent work on the Limpopo Belt, challenging its origin as an orogenic belt resulting from the collision of the Zimbabwe and Kaapvaal cratons. Recent precise baddeleyite dating of dyke swarms suggests proximity of the Zimbabwe, Superior and Karelia cratons, but not the Kaapvaal. This challenges the classic interpretation of the Limpopo Belt. The Kaapvaal and Zimbabwe cratons only share dykes from after 2000 Ma – post-Bushveld. This suggests the two Cratons only came together after 2000 Ma not 2600 Ma. Master with others suggests that the Zimbabwe Craton lay just off the Superior Craton with the Magondi Supergroup and Labrador Trough lying between the two. Piriwiri volcanics are post-rifting off the Superior block and close to the time of collision with the Kaapvaal at 2000 Ma. But, could not the Kaapvaal be just off the Zimbabwe Craton on the other side?

I, **David Love**, gave a talk on my preliminary work on the geology associated with Hwange (National Park) pans. I got two useful questions: does the current game water supply drilling programme provide any data? The South African Council for Geoscience has published a sub-Kalahari map that will also assist.

Two fascinating presentations on Ground Penetrating Radar (GPR) were given by **Dumisani Mapundu** and **Ed Magan**, the latter including some recent developments from the Russian space programme. A mobile GPR system (100 kg) can provide data from 1 m to 200-270 m

depth. Applications might be for tracking intrusions and also palaeochannels, deep alluvium, deep weathering etc. There could also be some application in gold mining. There are excellent implications for groundwater as the system was designed to find water on Mars.

Hillary Gumbo spoke on the use of geophysics in small mining projects and on claims. Expectations can be very broad and some service providers give out unrealistic results abusing the data to claim they can show gold grades! This is akin to giving a patient an injection – any injection – because that is what I have in my toolbox. Geophysics has its specific place in exploration and is not in itself the whole programme.

Gayle Hanssen spoke on her recent visits to Ethiopia and Iceland. The actual cracks at the spreading zone in the Danakil triple junction can be seen in the field. The three rifts and their junction can be seen and geological National Parks are being planned.

Tendai Njila made a presentation on the background to the geomedicine research programme that UZ is starting in Zimbabwe. Key elements are As Cd Hg Se F Pb and Cr. He mentioned high levels of Cd in the Pungwe River – this is interesting in the context of what has been seen in the Limpopo Basin.

Prof. Isidro Manuel presented on artisanal gold mining in Mozambique. Of interest in addition to the typical impacts of ASM as reported in the MMSD work, is a major problem with child labour. Access to formal credit is a problem for the miners, as is often the case with small-scale rural livelihood strategies. In addition to the environmental and social problems, and lack of management structures, ASM in Manica is unsustainable due to lack of knowledge of reserves and hence a lack of proper planning.

Bornwell Mupaya presented on the diamond deposits of the Umkondo Supergroup: Marange-type, associated with basal arkosic conglomerates of the Calcareous Series. The contact to weathered basement is gradual. The diamonds are brown and with a completely worn primary surface. Chikwakwa-type is similar to Marange but in a matrix-supported conglomerate with fewer clasts. The Chimanimani deposit is hosted in conglomerates in the Lower Argillaceous series. The cement is quartz rather than feldspar. The deposit also has the classic suite of heavy minerals, unlike Marange. The diamonds are well formed and in many cases polycrystalline. They have a wide range of colours. The Chinyadadzi-type is a Karoo-related diamond suite from just north of Birchenough Bridge.

REE and Phosphate Mineralisation in the Nkombwa Hill Carbonatite, Zambia

Jock Harmer and Mike Kellow

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The Nkombwa Hill carbonatite is located in the Muchinga Province in north-eastern Zambia and lies within the Luangwa Valley rift segment of the western arm of the East African Rift system. The intrusion is composite, built of several phases of intrusion of carbonatite magma of magnesian composition: the earliest recognisable phase is a relatively uniform-textured, medium-grained dolomite carbonatite, which makes up the bulk of the intrusion. Reaction between this dolomitic magma and the gneissic country rock produced a phlogopite carbonatite, which is found as a discontinuous marginal facies. Vari-textured, coarse to pegmatoidal, iron-rich carbonatites occur as large lensoid to sheet-like bodies within the dolomite carbonatites: although generally concordant with the foliation in the earlier carbonatite, cross-cutting relationships are sometimes seen suggesting these represent a later intrusive phase. Carbonate minerals are iron-rich ankerites while dark, interstitial siderite

is common. Vari-textured carbonatite is most abundant in the upper levels of the northern parts of the hill. All of the carbonatites are sub-vertically disposed. Iron-rich cherty rocks cap the central parts of Nkombwa Hill and represent pervasive silica alteration of the various carbonatites.

The pegmatoidal vari-textured carbonatites have elevated REE contents, commonly reaching ore grades of 3-10% total rare earth oxides. Apatite is an abundant primary cumulus mineral in the dolomitic carbonatites. Hydrothermal remobilisation of apatite has generated high phosphate concentrations within the pegmatoidal carbonatites hosted in secondary apatite and isokite (CaMgPO4F). Current exploration data suggests that zones of phosphate and REE mineralisation are spatially distinct. Phosphate and REE mineralisation also occurs within the silicified carbonatites: remobilisation of REE and phosphate minerals in the primary carbonatites re-precipitated predominantly as low-Th monazite-(Ce) with minor bastnaesite and traces of cerianite.

Current exploration results suggest that Nkombwa Hill offers the prospect of a high tonnage, easily mineable, multi-commodity deposit, which will produce economic rare earth, phosphate and agricultural lime products.

New U-Pb ages for the Palaeoproterozoic Magondi Supergroup, Zimbabwe

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The Palaeoproterozoic Magondi Supergroup is a metasedimentary succession with minor volcanic rocks, forming part of the Magondi Belt on the western edge of the Zimbabwe Craton (Figure 1a). It has been suggested in Master *et al*. (2010) that the belt extends through western Zimbabwe and northeast Botswana to include the Dete-Kamativi Inlier and the Matsitama Belt respectively. In the low-grade (greenschist to amphibolite facies) part of the Magondi Belt, there are three groups – the Deweras, Lomagundi and Piriwiri, while in the high grade parts of the belt, there are intrusive granitoids dated at about 2 Ga (Figure 1b).

The Lomagundi Group is the type locality for the "Lomagundi" global high δ13C excursion in marine carbonates Master *et al*. (2010), but its age is very poorly constrained. This study aims at improving the geochronology of the Magondi Supergroup, for both local and global geologic and chemostratigraphic correlations.

The currently available geochronology for the Magondi Belt is sparse and in some instances no longer valid, due to large errors. There have been some newer studies such as McCourt *et al*. (2001), which have U-Pb dates but more still are needed to constrain both the timing of the deposition of the host sediments and consequently when the Lomagundi excursion occurred.

Zircons from five samples were analysed using the SHRIMP-RG facilities at the ANU in Canberra. Only zircons with ± 10% or less discordance are considered in the age calculations.

DV 11/1 is a pyroclastic mafic agglomerate (with mafic clasts in a chlorite-plagioclase-rich matrix), and DV 11/2 is an overlying wackestone, rich in mafic lithic clasts, both from the base of the Deweras Group. The zircons from DV 11/1 give mainly Archaean ages, ranging from 2580 ± 19 Ma to 2813 ± 23 Ma with an age peak of c. 2.63 Ga, reflecting derivation as xenocrysts from the underlying Neoarchaean terrains of the Zimbabwe Craton. The youngest zircon grain, dated at 2235 ± 32 Ma shows good igneous zoning, though it is not euhedral, and could be either indigenous or xenocrystic, giving a maximum age for the Deweras Group. The 67 zircons studied in DV 11/2 are mainly Neoarchaean, with a bimodal age distribution, with peaks around 2.64 Ga and 2.86 Ga, and a total absence of ages between 2.70 Ga and 2.80 Ga. There are only two Palaeoproterozoic zircons, with ages of 2439 ± 23 Ma and 2171 ± 11 Ma. The youngest age provides a maximum age for the wackestone, and for the rest of the Deweras Group.

A lithic crystal tuff in the upper Lomagundi Sakurgwe Fm (Z11/C–SKR2B) contains a xenocrystic population of Palaeoproterozoic zircons ranging in age from 2070 to 2492 Ma, and an Archaean population ranging from 2604 to 2719 Ma. The youngest zircon age of 2070 ± 17 Ma provides a maximum age for the tuff. A felsic agglomerate from the Nyamakari "centre" within the Lomagundi Group (NC 1), consisting of an altered assemblage of alkali feldspar, quartz, carbonate and haematite, yielded only a xenocrystic zircon population dated at between 2615 and 2860 Ma, with a distinct peak at about 2635 Ma. There are numerous younger discordant zircons in this sample, which would yield upper intercept ages between about 2.1 and 2.2 Ga, but they are too discordant to yield reliable ages. A felsic crystal tuff from the Godzi "centre" in the Piriwiri Group (GD-

Z/11-2A) contains many discordant zircons, and among the more concordant zircons it has a large xenocrystic population of Palaeoproterozoic zircons, ranging from 2051 to 2492 Ma, and numerous Archaean xenocrystic zircons with ages ranging from 2558 to 3339 Ma. The youngest peak in the age distribution is at 2115 Ma, however, the youngest zircon age of 2051 ± 9 Ma may provide a maximum age for the tuff.

These results indicate that the basal Deweras Group volcanics are younger than 2235 ± 32 Ma, while the rest of the Deweras Group is younger than 2171 ± 11 Ma. Volcanic tuff units in the upper parts of the Lomagundi and Piriwiri Groups indicate maximum ages of 2070 ± 17 Ma and 2051 ± 9 Ma respectively. Since all these age constraints are obtained from just one zircon grain in each sample, more data is needed to confirm them.

Additional work is currently underway to obtain more dates, not only for the main exposed part of the Magondi Belt but also for the Dete-Kamativi Inlier, in western Zimbabwe, where high-grade metamorphosed supracrustals of the Malaputese, Kamativi, and Tshontanda Formations are regarded as possible equivalents of the Deweras, Lomagundi and Piriwiri Groups (Master, 1991, Master *et al*., 2010).

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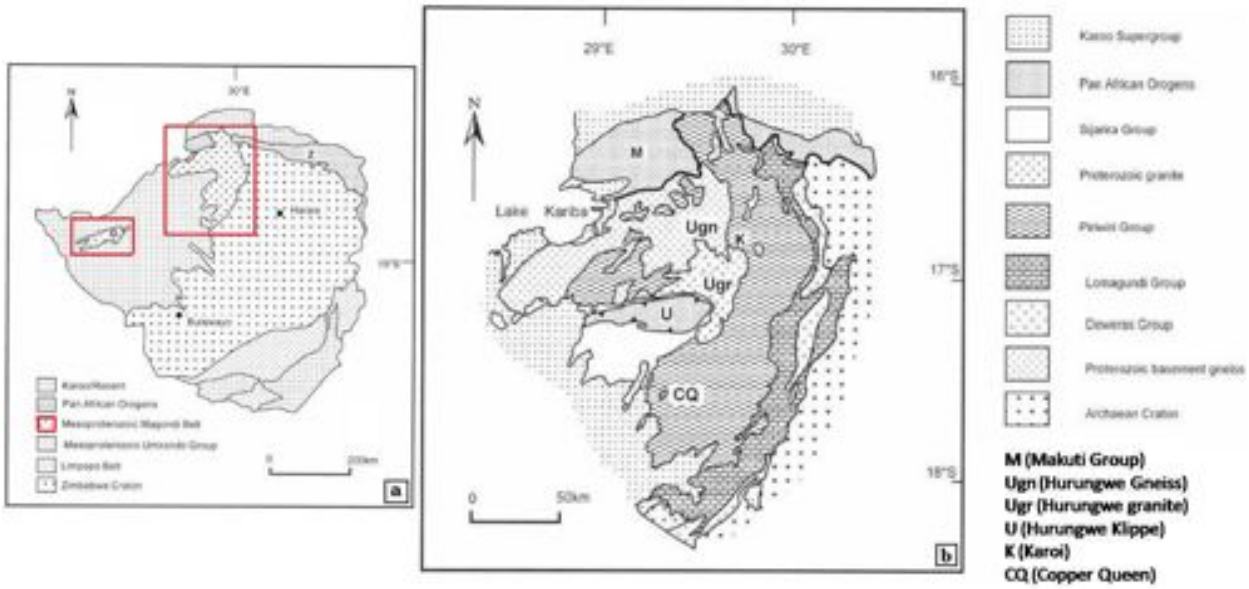

Figure 1. Fig. 1a – Geographical position of the Magondi Belt and the Dete-Kamativi Inlier in Zimbabwe. Fig. 1b – Main exposed part of the Magondi in NW Zimbabwe, modified after McCourt et al. (2001).

Geology and Petrology of the Umkondo Diamond Deposits with Emphasis on the Chimanimani Deposit

S.N. Petuxov, O.Y. Simonova and F.B. Mupaya

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In Zimbabwe, there are three known formational types of ancient diamondiferous alluvia related to clastogenic formations of marine origin, hosted in the Proterozoic Umkondo Basin, namely the Marange-type, the Chimanimani-type (Haroni River valley) and the Chinyadadzi-type of Karoo age, the latter located south-west of Hotsprings. Interestingly, all three formations are geographically close to each other. Ironically, with such a blessed unique geology, the scientific and geological information from the deposits is scanty. If scientific geological information is systematically generated and synthesized, this will result in increased exploration efforts in the Umkondo Basin, and perhaps provide analogues with other sedimentary basins in the country.

In this article, the geology, litho-stratigraphy and litho-petrographic compositions of the host conglomerates of the Marange deposits and the Chimanimani deposits are presented. It is shown here that the Marange conglomerates overlie basement granite whilst the Chimanimani conglomerates form part of the Lower Argillaceous Series, i.e. they occur in the Upper stratigraphy of the Umkondo Basin. Also, the two deposit types differ in their litho-petrographic compositions, where the Marange conglomerates are a coarse-grained quartz-feldspar variety. The feldspar is xtent of s ed pinkish-red K-feldspar that often cements the conglomerates. In contrast, the often metamorphosed Chimanimani conglomerates have smaller pebbles ina porous quartz matrix. Daily heavy mineral concentrates generally contain magnetite, ilmenite, limonite, tourmaline; single signs of zircon, diopside and picroilmenite. In the Chinyadadzi area north of Birchenough Bridge are Karoo sediments, which are associated with younger Mesozoic marine sediments: boulder conglomerates, grits and sandstones. The composition of the debris is polymictic: sandstone of different colours and grains, argillites, cherts and rarely dolerite. The cement is porous, sand and clay. Worldwide, this deposit-type contains in some places minor contents of diamonds, though here investigations are on-going.

Diamonds from the Marange deposits are generally rounded and the majority have a brown coating, probably due to radioactive effects of the basement granites. A careful study shows that despite these masking effects, the deposit yields diamonds of various morphologies such as octahedrons and flaky types. However, the Chimanimani deposit has quite a huge variety of these diamond morphologies, including well-formed octahedral crystals. Textured surfaces are predominant due to primary diamond etching in the magmatic melt in the form of triangles of dissolution and parallel striation. Another notable feature in these diamonds is colour. The Chimanimani deposit has a wide variety of colours with particular colours for each size fraction.

Indeed, the differences in the diamonds of the Umkondo basin have some genetic and age bearings on the host-formations. Especially that the formational types have differences both in stratigraphic position, mineral composition and morphology of diamonds

Notes on Diamonds in the Umkondo Basin

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Background

De Beers discovered the Marange fossil placer diamond deposit in 2003 during the tenure of their exploration licence (EPO 1523) covering the Marange area. Their exploration was targeted at discovering kimberlitic diamonds, but the recovery of rounded diamonds in some heavy mineral samples collected from local streams led to suspicions of a secondary source for the diamonds. A search for the possible source led to the discovery of a diamondiferous conglomerate.

The discovery attracted informal miners from all over the country and abroad. The chaos that ensued led De Beers to voluntarily abandon the area. The government immediately reserved the ground and introduced measures to bring order. Special licences (Special Grants) were issued

to the Zimbabwe Mining and Development Corporation (ZMDC) to systematically exploit the resource.

The influx of illegal miners and the leakage of diamonds to illegal markets resulted in Zimbabwe being put on the Kimberley Process Certification Scheme (KPCS) agenda in 2006. Several KPCS review missions were made to Zimbabwe to assist the country to comply with the minimum requirements of the KPCS. As a result, the ZMDC was advised to seek strategic partners with requisite capital to exploit the diamonds without compromising conditions of the KPCS.

The Marange diamond area is now secured against illegal mining activities, and four companies are commercially exploiting the resource. Families that have been disturbed by the mining activities have been re-settled.

The discovery of diamonds at Chiadzwa in Marange triggered an unprecedented diamond rush, which culminated in more discoveries. Other discoveries were made on the Chikwakwa plateau under Chief Muusha, and on Charleswood Farm east of Chimanimani village. The Charleswood deposit is being evaluated by the DTZ-Ozgeo company.

The Marange Deposits

The diamonds are concentrated in a basal conglomerate horizon that outcrops sporadically along the edge of the Umkondo basin in the south-eastern part of Zimbabwe. The conglomerate lying over an Archaean granite basement forms base to the 1100 million year-old Umkondo Group of rocks, made up of a thickness of over 1200 metres comprising various sediments, basaltic lava flows and intrusions and dolerite.

The most easily accessible exposure of the basal conglomerate is at Birchenough Bridge where it lies on a pink granite basement. The conglomerate is in turn overlain by a calcareous horizon, the so-called lower limestone horizon. This assemblage depicted as ml_1 on the 1: 100 000-scale geological map of the area (Watson 1960) is an important exploration guide for the diamondiferous conglomerate.

The diamonds are imbedded in the conglomerate, and also occur in residual and colluvial soils out from the edges of the conglomerate, and alluvially in local streams that drain the conglomerate (Figure 1).

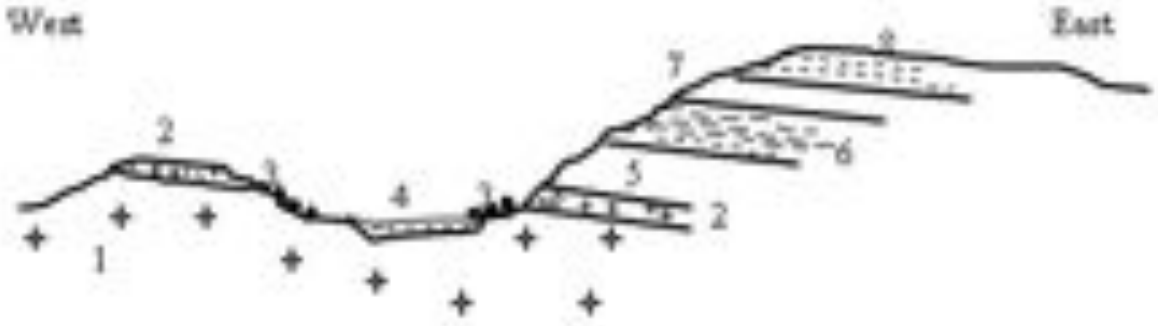

Figure 1. A generalized cross section across the Chiadzwa placer diamond deposit area. 1. Granite basement; 2. Diamond-bearing Umkondo basal conglomerate and arkose; 3. Diamond-rich eluvium shed from the conglomerate; 4. Diamond-rich alluvium; 5. Lower limestone horizon; 6. Lower quartzite horizon; 7. Upper limestone horizon; 8. Upper quartzite horizon.

The conglomerate, which locally grades into a grit, comprises well-rounded quartz clasts supported by an immature arkosic matrix that resembles the local basement granite in colour and texture. This tends to suggest that the provenance of the conglomerate materials was both local and distal. The conglomerate that dips shallowly to the east is typically 2-3 metres thick, thinning out laterally to a few xtent ofs.

The primary sources for Marange diamonds have not been identified. Several kimberlites are known to occur within the environs of the Marange area and beyond. These are, however, much younger than the age of the Umkondo sediments, and cannot be the sources of the diamonds in the ancient conglomerate. It is therefore possible that some diamonds in the later alluvium of (diamonds in location 4 in Figure 1) could have come from kimberlites found in the Marange area.

A large percentage of Marange or Chiadzwa the diamonds are sub-rounded (Plate 1), suggesting that they could have come from a very distal source. Sedimentological studies of the Umkondo sediments show that the basin was fed by rivers coming from the west (Button, 1978) off the Zimbabwe Craton. Thus it might be assumed that Archaean or early Proterozoic age kimberlites intruding the craton supplied the diamonds to the Umkondo basin. The diamonds appear to have been deposited in suitable environments along the beaches of an ancient sea in the Umkondo Basin. In a similar way diamonds are currently being deposited on the west coast of southern Africa, but despite the lengthy travel distance they are demonstrably less rounded than those at Marange. Could this roundness, therefore, be due to attrition of stone upon stone during wave action?

A unique feature of the Marange diamonds is the brownish colouration on the outer surface of some stones. This is believed to be the result of surface geological processes in the sedimentary environment and the subjection of the stones to radiation emanating from the basement granite, as well as to high heat and pressure resulting from the extensive intrusion of dolerite sills, and to effects of the Pan-African orogenesis that affected the Umkondo basin. Many of ththese stones exhibit a high degree of internal fracturing. Thus a large percentage of the diamonds are of poor quality, it being estimated that only about 10% of the stones are of gem quality. The sheer concentration of diamonds locally, therefore, makes the Marange deposit viable.

The Marange diamond deposit has not been well studied yet. For instance, the extent and controls of diamond mineralization are not known. Other technical data such as grade mixture, quality and resources of the deposits remain confidential or are not yet known.

The Muusha Deposit

An area across the Chikwakwa Plateau, under Chief Muusha, was invaded by informal miners after diamondiferous scree was discovered at the foot of the escarpment. They followed the scree until they got to a gritty quartzite horizon close to the summit of the mountain. The quartzite horizon, which averages 5 cm in thickness, was extensively worked for diamonds through adits and open pits. Diamonds recovered by the informal miners are generally smaller than those found at Marange.

The diamondiferous quartzite lies on granite and is in turn overlain by carbonate rock and other sediments. Thus the deposit occurs in the same geological setting as at Marange. However, here the conglomerate is not well developed, being only a thin grit rarely exceeding 10 cm in thickness. It would appear that this area is distal to the main depositional point and hence the accumulation of smaller clasts and associated smaller diamonds.

Charleswood Deposit

Following discovery of alluvial gold at Tarka Forest in 2004, and subsequent acquisition of a Special Grant over the area by the Zimbabwe Mining Development Corporation, a lot of interest arose concerning the gold potential of the Chimanimani area. This resulted in DTZ-Ozgeo, a company specialized in alluvial minerals, securing a Special Grant (SG 4955) in 2007 to explore for gold in an area encompassing Charleswood Farm adjacent to and to the north of Tarka Forest, and about 15 km east of Chimanimani village.

The issuance of the Special Grant was coincidental with the discovery of diamonds at Charleswood Farm by artisanal miners. The illegal miners occupied an area about the size of a football pitch where a gritty quartzite body is exposed close to the Haroni River.

Having realized that there could be a potential for diamonds in the area, DTZ-Ozgeo requested the inclusion of diamonds in their exploration portfolio. This was granted in 2010. Several diamond experts were invited from Russia, South Africa and Namibia to ascertain the potential of this deposit. A small testing plant was set up to process material from trial mining in the area.

The diamonds occur in a gritty quartzite and associated later eluvium. The 1:100 000-scale map of the Chimanimani area shows that the quartzite belongs to sediments of the Lower Argillaceous Series of the Umkondo Group (Watson, 1969). The Charleswood rocks lie stratigraphically above the Calcareous Formation that hosts the Chiadzwa and the Muusha diamond deposits farther west. They appear to belong to the Upper startigraphy of the Umkondo basin (Petuxov *et al*. 2012). Discovery of diamonds at Charleswood Farm therefore has far-reaching geological implication that call for careful structural, stratigraphic and sedimentological understanding.

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Report on the Geological Society Field Trip to the Marange and Chimanimani Diamond Fields – 1 & 2 December 2012

Daniel Chatora

Introduction

The trip formed part of the 2012 Annual Geological Society of Zimbabwe Summer Symposium, which started with technical papers on 30th November at the University of Zimbabwe.

The trip had attracted a lot of interest from a wide spectrum of people including geologists, students and mining engineers. On the morning of 1st December a group of 86 delegates converged at the rendezvous point, Hot Springs, approximately 80 km south of Mutare.

The group included Dr Sharad Master a leading researcher on the Umkondo Group in Zimbabwe. He is also a lecturer at Wits University in South Africa. Gordon Chunnett, representing the Geological Society of South Africa, also made the trip to Marange. Besides South Africans, the group also included Botswana, Mozambique, New Zealand, British and Russian nationals. A bus ferried the team to the Marange Resources Processing Plant site where it was received by the CEO, Mr E. Mabhudhu, and the Geology Team led by Miracle Muusha.

Geology

Following induction Miracle gave an overview of the geology and controls on diamond mineralization. The stratigraphic sequence is as follows:

- Intrusive dolerite dykes and sills
- – – · – · – · – · – · – · – **Unconformity**
- Mafic volcanics
- Sandstone, quartzite, shale
- Upper limestone / lower limestone
- Sandstone
- Grit
- Basal conglomerate
- – – · – · – · – · – · – · – **Unconformity**
- Archaean Granite

The sequence starts with Archaean granite, which is unconformably overlain by a basal conglomerate grading upwards into a coarse-grained sandstone or grit overlain by further sandstone. A shale horizon sits above the sandstone followed by a thick limestone formation. On top of the limestone formation is a sequence of sandstone, quartzite with a mafic volcanic pile capping the Umkondo Group. The whole package is intruded by coeval and younger dolerite dykes and sills.

Controls to Diamond Mineralisation

Diamonds occur in three broad horizons:

i. Conglomerate / grit / sandstone of the basal Umkondo Group
ii. Recent eluvium
iii. Recent alluvial

- The greyish pink clast-supported basal conglomerate with sub-rounded to rounded granite, feldspar and quartz pebbles is the major host rock for the diamonds. These placer diamonds are themselves mostly sub-rounded to rounded, up to 8mm in diameter, although there are reports of larger stones. Angular and well-shaped octahedral and rhombohedral stones have also been reported, which would indicate that the source of the diamonds proximal. The conglomerate horizon is generally less than a metre in thickness. Diamonds also occur in the grit horizon overlying the conglomerate, but are in lower concentration. At the time of the visit, Marange Resources were mining bulk-sampling pits within the two hardrock horizons. The sandstone was said to be hosting diamonds in uneconomic concentrations. The suite comprising the conglomerate, grit and sandstone is up to 15 metres in thickness. In the end mining is likely to be only in the conglomerate and part of the grit horizon.

- The eluvium or eluvial diamond deposit occurrences at the Marange Resources Concession are those that have been derived through *in situ* weathering of the bedrock and gravitational movement and accumulation of the debris. The source is from outcropping conglomerate, grit and diamond-bearing sandstone.

- Alluvial diamond occurrences in the Concession area are a process of redistribution of material due to rainfall runoff and sheetwash into streams, rivers and palaeo channels as a poorly sorted composition of silt and clay and larger particles of sand and gravel.

At the time of the visit the bulk of the mining was taking place from the eluvial and alluvial deposits. The visitors were taken through the mining areas by Miracle and his team.

The Conglomerate outcrop near Birchenough Bridge

After the Marange Resources visit, delegates stopped to study an outcrop displaying the contact between the Archaean Basement and the basal Umkondo conglomerate 1 km west of Birchenough Bridge. The lower limestone unit is also well exposed in the Masvingo road cutting and is similar to that exposed in the Marange Diamonds Fields. However, there is no mining activity at Birchenough Bridge, suggesting that barren tracts of the basal unit can be expected.

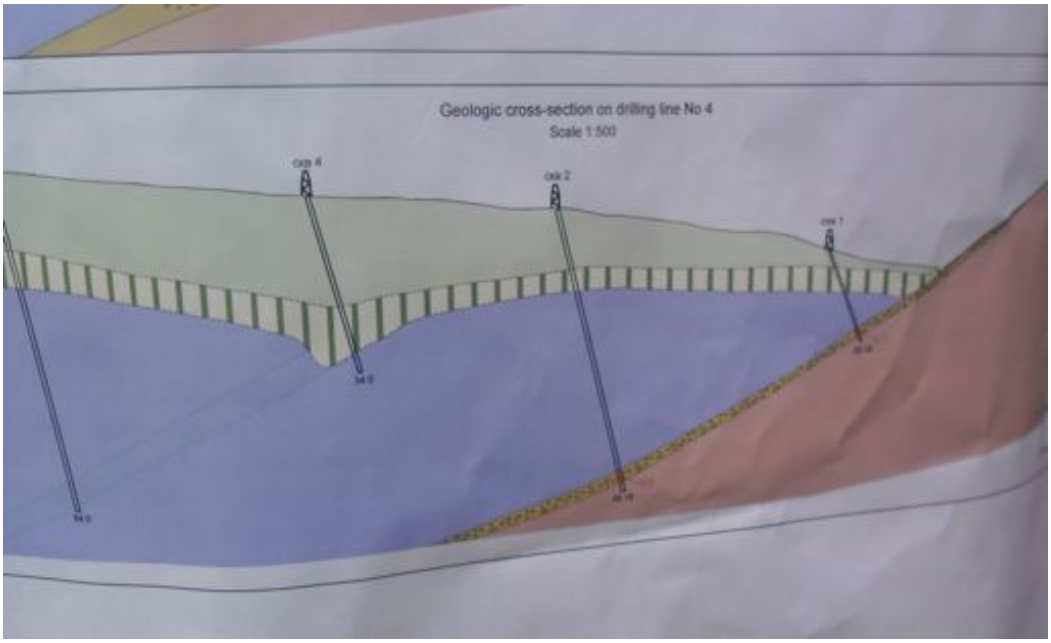
The Lower Unkondo Limestone Unit and the Basal Umkondo Conglomerate in direct contact with the Granitic Basement in exposures close to Birchenough Bridge. No Diamonds! PHOTOS: per Daniel Chatora

The Chimanimani visit

From Birchenough Bridge the group drove to Chimanimani were they put up for the night. We are grateful to DTZ-OZGEO for hosting our supper and for allowing us access to their exploration operations in the Chimanimani Special Grant (SG) 4955 on Charleswood.

While exploring for gold, the Russian company discovered diamonds in a 2.5 to 3.6 metre-wide conglomerate horizon within the Umkondo Group. The difference compared to the Marange conglomerate is that the host horizon at Chimanimani occurs above a conformable sandstone itself overlying an Archaean gneissic basement.

The company has completed detailed mapping and drilling along a 1.2 km xtent of the conglomerate horizon to come up with a resource that they say is enough to feed an envisaged plant for 5 years. At the time of the visit there was a 20-ton per hour exploration plant which was to be moved as it is located above the ore zone. Preparations for construction of the new plant were well advanced.



A Geological Cross-Section through the Chimanimani Diamondiferous Conglomerate. PHOTO: per Daniel Chatora.

On their return the group made one stop on the road near Mutambara where Sharad Master walked the team through an outcrop of the upper Umkondo shale and sandstone, which are capped by mafic volcanics. This horizon is known for the its small-scale copper and gold enrichment, a situation which arguably could be the source of the gold occurrences that caused the rush in the Tarka Forest area in 2003. At about 13:00 hrs on Sunday 2nd December 2012 this became the last stop on this exciting field trip with everyone agreeing that we should have more of the same.

The Geology of Health - An Overview

Dr. T. Njila[1], Prof. I Manuel[1], Dr. M.L. Meck[1], Ms D. Mudimbu[1], Dr. P. Chikwema[2]

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Introduction

Geochemical anomalies of arsenic, cadmium, mercury, (radon) and chromium in soils, sediments, and water that may adversely impact human and animal health; Sampling in these media is required to assess the possible health impacts of these anomalies. Data collection from public health and related professionals is fundamental in trying to find lasting solutions to prevent or minimize these problems. Interaction and communication is necessary between the geoscience, biomedical, and public health communities to protect human health from the damaging effects of physical, chemical and biological agents in the environment.

Toxicity and diseases due to essential and non-essential geologic material deficiencies and excesses

Some of the common medical conditions caused by deficiencies and excesses of known chemical elements in geological spheres include different types of cancers caused by Arsenic, Cadmium, Lead, Chrome, Mercury and Cobalt; cardiovascular diseases and dental fluorosis are due to these and other toxic chemical elements.

Brief overview of the situation in Zimbabwe

Zimbabwe's health services were the last segment of the public sector to collapse in 2008, and the Ministry of Health and Child Welfare was the first to recover after the inclusive government was formed in early 2009.

This collapse presents a major setback to the already sidelined public and ecosystem health issue regarding the geological impacts on these health sectors. No research is currently in place to gather information and provide solutions to the medical conditions caused by naturally occurring geological elements.

Discussion

Having reviewed the sources referred to in this paper, it can be implied that a large number of locals in mining towns (e.g gold, coal mining centres), and artisanal miners, as well as the ecosystems themselves, are prone to contracting and harbouring diseases due to water and food poisoning.

In view of the fact that the Zimbabwean economy is highly strained, tackling the issue of health hazards presented by mining and geological toxic elements equates to a mammoth task. This can be reflected by the struggle in other developing countries (e.g South Africa) to find lasting solutions to such matters.

There is need to tackle the issue of dental fluorosis in areas like Mount Darwin and Gokwe. The unavailability of information and funding is hindering research in the field of Medical Geology, which, in essence, relates to human and ecosystem health from a geo-environmental point of view.

The Geological Society of South Africa: A View from Johannesburg

Gordon Chunnett & Craig Smith

GSSA

craig.smith@gssa.org.za & gchunnett@yahoo.com

The Geological Society of South Africa (GSSA) was established in 1895 in response to the needs of the earth science professions to develop a better understanding of the geology of South Africa, established even by then as one of the world's major minerals producing countries. The Society was established to promote the study of geology, and to look after the professional well-being of those who practice it, whether in industry, academia or government sectors of employment. Since 1895, there have been many changes to the science and to exploration and mining as well as to the GSSA, yet the broad strategic goals of the Society have remained the same. Importantly, the GSSA serves as both a 'learned' and 'professional' society, unlike some of its larger counterparts in the developed world. The GSSA is growing rapidly, now closing in on 3500 members, and routinely having five to six million Rand annual budgets. For some years it has not been possible to manage the Society on volunteer labour alone. Currently the GSSA employs four full time staff, and will probably need to add more with increased growth. We see growth continuing, given the emphasis on the minerals sector in Africa, as well as the GSSA's involvement in drafting of minerals reporting codes, and its ROPO status with several overseas organizations.

A major benefit for members of the GSSA is the recognition of his/her status as a professional geoscientist. The SAMREC/SAMVAL codes, along with other reporting codes elsewhere in the world, require continued membership in a professional society as a basic requirement. Any professional needs to be subject to a code of conduct or code of ethics, and must also be subject to oversight as regards the quality of his credentials and track record.

Support for the academic community is supplied through cooperation with research funding organizations and direct financial grants by our REI (Research and Education Investment) Fund. The GSSA continues to publish quarterly a full scientific journal, the *South African Journal of Geology*, which continues to be read around the world, either in its physical format, or in its digital guise via Geoscience World. As is the case with other Societies, a current hot topic is when or if we move to full digital publication, dropping the print version. The digital is in fact the official version of record. For now we retain both options, as has *Economic Geology*.

The GSSA also publishes the quarterly news bulletin, *Geobulletin*, an increasingly popular source of news and forum for comment in the southern African earth science community.

The general 'landscape' we see in the global minerals business as well as in geology R&D lead us to believe that the GSSA has an increasingly important role to play in the continued professional and academic development of its members, and supporting exploration and mining geology in Africa, inter alia by arranging courses, workshops and conferences, and by interacting with government with respect to legislation that may affect the profession. Africa is developing rapidly, and clearly will be a major target for exploration and mining investment world-wide. There will be hiccups along the way, such as the current labour unrest affecting the South African sector. But in a world with 7 to 10 billion people, half of whom live in developing countries, increasing numbers of professional earth scientists will be required in all sectors of the economy. The GSSA will continue to support their needs, as well as serve the best interests of the public.

News

Geology Department, University of Zimbabwe

Maideyi Meck

The situation at the Department continues to improve. **Dr Mulugheta Tewelde** joined us in November from Germany. The expected professorial candidates were not appointed. UZ no longer employs professors on the basis of publication alone as a PhD degree is now required on top of the publications. **Dr Maideyi Meck** resigned as chairperson of the Department in December and the new chairperson is **Dr Nhamo** from Chemistry. However, Dr Meck is still teaching in the Department.

The new Honours class is now running with 27 students. Most of them have performed well in their first semester, with only a few not struggling. This is partially accounted for by the high points the students had (cut-off for geology was 10 points). The student's Mennell Society is up and running, and many thanks go to the GSZ and some companies who made it possible for the Many of their members to travel to Marange following the summer symposium.

The Part I field excursion is expected to take place around May. We are appealing to geologists in the industry to help run the trip and also to provide or suggest interesting new sites for us to explore. The Department will be grateful for any form of assistance (supervision, transport, fuel, cash or kind to help keep the momentum going).

Dr Meck has been elected as Councilor of the Geological Society of Africa for the Southern African Region (2012-2016) term, and will happily forward any news/discovery from Zimbabwe to the GSAf Newsletter, as well as item that may advance Earth Sciences Development for the benefit of Africa and its people. It is noted that Dr Benjamin Mapani was elected Secretary General to GSAf for the same period.

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DG Direct line/Fax:	263-4-303557			

Note: DG – Department of Geology; MRC – Mineral Resources Centre; GSZ – Geological Society of Zimbabwe

ZIMBABWE

Geological Survey Department

Staffing
The professional staffing situation has not changed. The following members are in office.

Name	Post
Hawadi, Temba	Director
Mugumbate, Forbes	Deputy Director
Lunga, Sokesibone Mugandani, Ernest Mpindiwa, Sibongubuhle Muzanenhamo, Frank Kashiri, Tendai Maisera, Mitshell	Geologist/ Senior / Principal
Shawarira, Lloyd Ndoro, Mathias	Geophysicist /Senior/ Principal

Sibongubuhle Mpindiwa and **Ernest Mugandani** attended a week-long training course in mineral exploration and remote sensing in Botswana organised by the Japan Oil and Minerals Corporation (JOGMEC). JOGMEC has set up a training school in Botswana for African geoscientists from the Sub-Saharan region. Zimbabwe did not fully benefit as other countries did because there has not been a signing of a Memorandum of Understanding between the Zimbabwe Geological Survey and JOGMEC.

Tendai Kashiri and **Mitshell Maisera** are in Japan for a three-month course in mineral exploration. The course is sponsored by the Japan International Cooperation Agency (JICA). Apparently Japan is renewing interest on Zimbabwe's minerals industry. The country is carrying out a study of the mining industry of Zimbabwe with the intention of identifying areas where they could intervene or invest. Two groups have already visited Zimbabwe in November 2012 and January this year.

Forbes Mugumbate

MINING INDUSTRY NEWS

Forbes Mugumbate
fmugumbate@gmail.com

As we get into the year 2013, the mining industry continues to grow steadily in terms of recovering from the devastating effects of the economic melt-down of the recent past. Gold production that had declined to 3t in 2008, rose to over 13t in 2012, and is projected to reach 17t in 2013. There were also marked increases in diamond, platinum group metals, and coal production. However, apart from the diamond and platinum sectors where there are noticeable increases in activities, the growth of the mining sector in real terms is not discernible without new exploration projects. The country has lost a decade of systematic exploration in green- and brown-field projects. There are no current Exclusive Prospecting Orders.

The following are highlights relating to some developments in the mining industry.

Mining Legislation

After close to a decade of attempting to amend the Mines and Minerals Act Chapter 21:05, the Government has now made a decision to abandon the project and pursue the route of crafting a new Act. It proved insurmountable to amend such a complex Act that is akin to a procedures manual. The Government is now taking advantage of this development and will start by producing a minerals development policy that will form the foundation on which the new Act will be built.

The much-awaited Diamond Policy has now been published, and will be officially launched at a date to be announced. The Policy will lead to amendments of the Precious Stones Trade Act to accommodate diamond exploration, mining and trading issues as well as promoting development of the diamond industry.

Indigenization and Economic Empowerment

A new Board of Directors led by Retired Lt General Mike Nyambuya has been appointed to run the affairs of the National Indigenization and Economic Empowerment Board (NIEEB). The new Board is now in the process setting up regional offices. The decentralization, according to NIEEB, is meant to bring about integrity, accountability, social responsibility, patriotism and transparency. The Board has also promised that 2013 is the year to consolidate the gains achieved under the empowerment law. Small mining firms will be engaged to comply with the laws.

The implementation of the Indigenization and Economic Empowerment Act has gained momentum in the past two years with major mining firms complying with the Act, which has seen the acquisition of shares by local communities and workers. A number of projects are already underway after the implementation of community share trusts, which are believed to be the cornerstone of the empowerment programme, while the National Economic Empowerment Fund has accrued close to US$4 billion.

Meanwhile Zimplats Holdings has agreed to sell a 51% stake to “indigenous entities” for $971 million under indigenization laws. This is in spite of a report earlier in 2012 that the company

had resolved to drag its feet to buy time for possible changes in policy. The company would now retain a 49% interest and management of the Zimbabwe Platinum Mines. Under the deal, Zimplats will transfer its stake to Zimbabwean investors as follows: 10% to the community, 10% to Zimplats employees and 31% to the state-controlled National Indigenization and Economic Empowerment Fund. All shareholders will be required to contribute on a pro-rata basis for any future equity issues to finance expansion at the group's mines.

Alluvial Gold

The success of an alluvial gold project along the Mutare River in Penhalonga has triggered some sort of a gold rush in other parts of the country. There is now a virtual stampede especially by small companies to acquire concessions along rivers draining the gold areas. For instance, the whole course of the Mazowe River in Zimbabwe is now pegged. There are concerns that most of the companies acquiring these concessions lack the technical and financial capacities to take care of environmental issues associated with mining along rivers. Recently the Environment Management Authority (EMA) put a stop to all mining activities along the Umzingwane River to reduce water pollution and environmental degradation. A Chinese company, Tapin Private Limited was accused of causing a great deal of damage along the river. Damages of the same magnitude are reported on parts of the Mazowe River. As rivers are proving to be repositories of huge resources of gold, it is necessary for the government to issue concessions only to companies with requisite technical and financial capacities to mine in these highly sensitive areas.

Informal Mining

Informal mining activities continue with sporadic reports of gold nuggets that trigger local gold rushes. A number of prospectors have acquired metal detectors of various forms to search for nuggets. There is, however, a lot of confusion as to the capacities of these gadgets. A number of prospectors believe that the gadgets can detect buried gold-bearing reefs. As a result, the business of selling metal detectors has become lucrative.

Metal detectors have had a negative impact on the environment. Wherever nuggets are discovered, the area is turned upside down as miners expose new surfaces for searching. Large trees are occasionally up-rooted as some prospectors believe that large nuggets lie below the roots of the trees. Debate is currently raging on what to do with the metal detectors.

The ingenuity of prospectors was proven when some villagers recently discovered a tantalite deposit in the Dema area in the Seke Communal Land. An observant villager with previous tantalite mining experience gained in Buhera and Bikita noticed tantalite grains while gathering gravel from a pegmatite for building houses. He alerted other villagers who immediately started pig rooting the pegmatite for tantalite. Within days the area was invaded by fortune seekers, and has now been reserved to bring about order.

Tungsten

There are reports that Premier African Minerals, a company registered in South Africa, is carrying out exploration at the RHA tungsten deposit near Hwange. The aim of the company is to develop a low-capital- and low-operating-cost mine in the near future. A five-hole diamond drilling programme undertaken on site confirmed significant tungsten oxide values.

Tungsten mineralization at the deposit is in the form of very coarse wolframite crystals hosted by quartz veins. The company reports that the drilling identified previously unknown, well-mineralized quartz veins.

Developments at RHA are interesting in that they show that there is mining life outside gold and diamonds. Zimbabwe boasts numerous economic minerals yet not much is happening to develop the minerals despite high prices on the international markets.

The Chrome industry

The chrome industry is teetering on the brink of collapse due to deepening viability challenges. Smelters have either scaled down operations or closed down. The Zimbabwe Power Company increased electricity tariffs by 37% in September last year. This compounded by low prices of ferrochrome, has threatened the chrome industry. The upward review of mining fees has not helped the situation.

Bindura Nickel Corporation

Mwana Africa's Bindura Nickel Corporation (BNC) is on course to restart operations at Trojan mine in Bindura. The resuscitation is being phased. The first phase is to resume mining and to sell nickel in concentrates. The company has signed an offtake agreement with Glencore International who will purchase the concentrates. The first sale of concentrates is targeted for April 2013. It is hoped that the successful resuscitation of the Trojan Nickel Mine will attract capital that will be used to refurbish the smelter and start a new mine at Hunters Road.

Meanwhile there are reports of significant new discoveries at Trojan. Underground exploration has apparently revealed the "Mother Lode" of the mineralization. This is in the form of a massive sulphide body holding nickel values that range up to above 11%. As a result, the company is now revising its resource information in conformity with internationally accepted standards.

Renco Mine

There have been disturbances at Renco Mine that dented the normal serene mining environment of Zimbabwe. The problem started with spouses of workers blocking entrances to the mine to demand that their working husbands and wives be paid bonuses. This gradually degenerated into chaos and subsequent intervention by politicians who invoked indigenization issues. The case ended at the High Court where politicians who had taken control of the mine were ordered to leave. RioZim indicated that they had lost $150 000 in daily production during the stand-off and was finding it difficult to assert control over the mine. Things were, however, reported to be returning to normality at the time of compilation of this report.

Dalny Mine

In a similar case to that at Renco, New Dawn reported an illegal work stoppage at its Dalny Mine in January 2013. The stoppage caused gold production at the mine to halt. The Company, however, quickly dealt with the situation in accordance with Zimbabwe labour legislation, as well as its own internal policies, which led to the resumption of operations.

News about Zim Geoscientists

Johannesburg, 1 November 2012 - Professional services firm Deloitte has acquired mining services consultancy Venmyn, to create a new technical and economic minerals advisory business. The deal has resulted in Deloitte acquiring 100% of the current Venmyn business for an undisclosed amount and consolidates its existing mining advisory services practice into the new entity. The new business, "Venmyn Deloitte", will build on the two companies' successful track records in minerals consulting, mining advisory services, audit, tax, risk advisory, consulting and corporate finance services to the mining industry. Venmyn Deloitte will leverage the global Deloitte network to enable a global value proposition for technical evaluation and the financial valuation of mineral assets. Venmyn was formed in 1988 by Andy Clay and Willo Stear with Rand Merchant Bank after they left the then Rand Mines. Over the next 25 years, it has established itself as a pioneer in a range of technical and financial areas including the writing of short form reports and valuations with the Venmyn valuations curve. **Andy Clay**, Managing Director of Venmyn, will head up the new business.

We hope your contributions may improve with the Facebook initiative. Talk to you on the Geological Society of Zimbabwe Group, an open link. Join us there for better communication.

Please provide us with news about yourself or other geologists. We need to keep in touch with all of you out there. E-mail fbmpaya@yahoo.co.uk or makari@zol.co.zw

Conferences

Geoforum 2013 – The Geological Society of South Africa's premier event: 3 – 5 July 2013 in Johannesburg. Please reply to register@rca.co.za

The 23rd International Geological Congress, Cape Town, South Africa – 2016.

GSZ Research and Development Fund

Enquiries relating to the distribution of funds through this facility should be made through the standing Chairperson.

SEG Timothy Nutt Scholarship Memorial Fund

This fund will be available to provide financial support for geology students and young economic geologists located in Zimbabwe or in Southern Africa with ties to Zimbabwe. The fund may be used to support SEG student chapter activities, travel to meetings, field trips, for research or study grants, technical lectures or any other activities approved by the SEG Regional Vice President for Africa.

Applicants must describe what the project is, why the research is important and how it is to be done.

An estimate of expenses for the project must be included with the application.

Grants are expected to be fully utilized by year-end.

Grant recipients are required to provide a year-end accounting of how the money was spent together with a suitable progress report or final abstract.

See the Society of Economic Geologists website for further details and the next call for applications.

GEOLOGICAL SOCIETY OF ZIMBABWE:
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3D EARTH EXPLORATION (Pty) LIMITED

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3D Earth Exploration is a Botswana-registered company operating in the Africa theatre and provides the following services:

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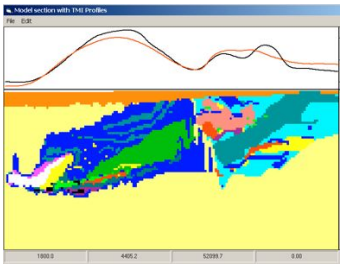
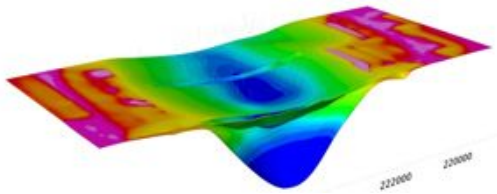
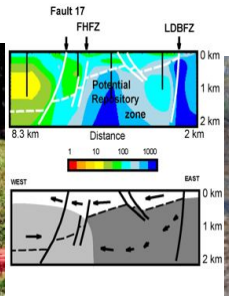
- Physical rock properties measurements …&… 3D Data processing and interpretation

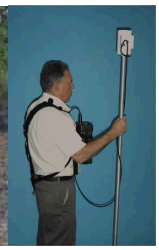

GDD MPP-EM2S+ Magnetic susceptibility and conductivity probe and axim ……..Onsite data processing

- 3D magnetic and gravity data modelling

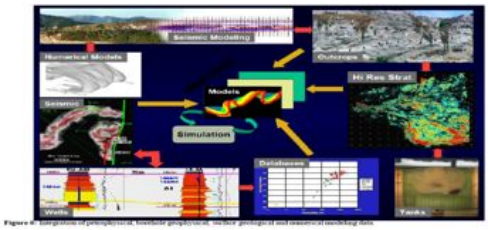



- CSAMT, ground magnetic surveys, Induced Polarisation, gravity (CG3/5, La Coste), rock properties, EM, GPR, radiometrics and a wide range of other ground geophysics surveys.



- 3D Data integration and visualisation



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Institutional Membership, 2012

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Zimbabwe Mining Investments

Zimbabwe Platinum Mines Limited