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Executive Summary

Much has been written about Africa’s non-renewable natural wealth (oil, gas, coal and minerals) and its potential to develop her economies and the quality of life of her people, but rather less has been said about the geodata public information that influence inward investment decisions and facilitate exploration.

Effective acquisition, maintenance and dissemination of geodata can act as a magnet to investment and can enable governments to understand better their natural resources in order to manage them most effectively. In recent years, many millions of dollars have been invested by bilateral and multi-lateral aid and development agencies on various geodata gathering projects in Africa, including associated capacity building and training programmes, with the intention that this would have a direct and sustainable effect on economic growth in the recipient nations.

In this report, as a starting point, a list has been made of the geodata for Africa that can be accessed through the internet, either directly to the geodata (a rare occurrence) or indirectly by showing the contact details of the data’s custodians. This is published on a country-by-country basis as a web enabled atlas through the EI Source Book. Remarkable little of the vast amounts of geodata known to exist can be sourced on-line and in most cases potential investors and other users of geodata must follow up through obscure and frequently non-functioning email addresses or telephone / fax numbers, which are given in the atlas wherever possible.

It is found that there is relatively poor spatial correlation between the principal geological structures of Africa and the currently known mineral locations. This may be explained in several ways but indicates that, with new approaches to geodata acquisition, many parts of Africa that are currently under explored may reveal great resource potential. Five such development zones have been identified which all involve trans-national corridors. The challenge will be to build survey programmes that cover parts of, but not all of, a number of countries and to arrange for the integration of these along natural or other infrastructure corridors. However there are significant obstacles to facilitate cross border cooperation in terms of geodata collection, maintenance and dissemination, even where there is a powerful case to be made on geological grounds so to do.

Results are presented of a survey of the extractive industries describing their perceptions of the usefulness of public geodata by type, resolution, quality and availability. It is fair to say that the industry is generally dissatisfied with the provision of public geodata by the bodies charged with their collection and administration, the national geological survey organisations. With a few exceptions, these are seen as rather ineffective in meeting the needs of the industry. Many of them persist with traditional models of systematic nationwide map coverage at the same scale regardless of geological indicators; most are underfunded and lacking in expertise so that they are unable to warehouse and disseminate effectively the information they hold over a long period of time. Even when boosted by a development project, the upgrading is in some cases lost after the programme ends, because of the lack of funds for post-project sustainability. In too many cases, the geological surveys are insufficiently outcome driven and focus on activities that are of little immediate benefit to the extractive industries sector.

Partly as a result of being poorly served by national geological surveys, the oil and gas industry has developed much greater self-reliance, taking responsibility for geodata at a much earlier stage in the

1 at www.eisourcebook.org/africageodata
investment and development life cycle. This trend is also being seen through a growing number of private sector initiatives in the mining sector, which unless well-coordinated and integrated into public geodata, may hold back macro-economic developments in parts of the region, where the norm is for junior mineral exploration companies to depend until a later stage on public geodata.

Building on the industry survey and with a view to future geodata activities, the technical aspects of the geodata themselves in relation to scale, resolution, amount of processing, interpretation and cost-effectiveness have been examined. It is found that for early stage, board room investment decision making, relatively low cost overview data are sufficient, and it is noted that such products for Malawi and South Sudan at costs of below $100 000 in each case have had a positive impact on attracting investment interest to those countries. However the requirement for exploration work is for relatively large scale geological maps and high resolution airborne geophysical data. In most cases the end-user is looking for rapid access to the data, even if still imperfect, in vector digital format suitable for further processing and interpretation by the company, rather than experiencing a long wait for polished products. Depth control and other information derived from boreholes are also required.

Noting the current inadequacies in data warehousing and dissemination, it is recommend that future bilaterally and multi-laterally funded geodata projects are set up to avoid some of the problems of the past, in particular that they are conditional on the output data being made freely available, albeit at a price to cover costs, through an independently operated, reliable and high bandwidth web server, and that a business model is developed to sustain that service well beyond the life of the project. This would not only have a positive impact on investment and development in the sector but it would largely eliminate issues of malpractice surrounding data release. The organisational and political barriers of storing public geodata on outside servers, perhaps funded from international sources, will need to be addressed.

Finally, ways are suggested in which retrospective action can be taken to make existing geodata more easily available to the industry, through supporting the release of geodata from African geological surveys as well as from archives in Europe, again noting the significant challenges that this presents.

In summary, appropriate geodata are essential to economic development through the extractive sector in Africa, but so far they are often poorly maintained, difficult to access and not sufficiently fit-for-purpose. Past practice in this field has not always achieved the optimum benefit and it is hoped that this report may stimulate new approaches to derive greater value from future development funding.
1. Introduction

Investment in the collection, storage and dissemination of publicly available geodata\(^2\) can potentially lead to high returns. As Gelb\(^8\) noted, this can be due to several factors including

- improved information to attract investors;
- increased government ability to negotiate contracts;
- additional discoveries; and
- development of resource corridors which rationalise extractive industries with supporting infrastructure.

The type and quality of geodata, their density of coverage, ease of accessibility and price are all critically important in the process. This is because

- costs are a function of the quality, quantity and type of data collected;
- certain types of geodata are more relevant for the discovery or evaluation of particular commodities and therefore may vary by geological province;
- some areas may be explored by the private sector giving the state the opportunity of leveraging on those investments;
- the type and level of coverage required may vary depending on its intended use; and
- geodata that are not well maintained and easily made available in suitable formats and at a reasonable price have limited efficacy.

This report examines these issues and in particular looks at, in relation to which geodata should be collected and potentially interpreted:

- The minimal and optimal scale of geodata required, for example, to stimulate resource bidding.
- The key differences for geodata requirements across oil, gas and other minerals/metal sub-sectors.
- The optimal level of data interpretation.
- Criteria for prioritising more in-depth geodata and the need for tiered prioritisation, such as completing a minimal level first, then performing an additional, and more intensive exploration programme on the most promising subsets.
- Rules by which sampling / coverage should be prioritised.
- The average projected cost (e.g., in sub-Saharan settings) of achieving geodata coverage at a minimal and / or optimal level giving the optimal level of coverage.

It also looks at the key institutional issues of:

- How the geodata can be warehoused and disseminated.
- Whether a regional approach should be taken or the solution should be customised to each country taking into account the issues of confidentiality and revenue generation.
- Given the requirement for specialist knowledge, how best to collect and interpret the geodata and whether in a potentially ambitious programme these skills and specialist equipment reside in country.
- Alternative mechanisms to public provision of geodata.

\(^2\) For simplicity, the term “publicly available geodata” is abbreviated to “geodata” from here on
2. Atlas of Geodata for Africa

As a starting point, the existing levels of geoscience data for Africa have been identified, showing as far as possible the principal sources and types of geodata, where they are located and how they may be accessed. This is available within the EI Source Book at www.eisourcebook.org/africageodata

Whilst this atlas will inevitably be incomplete, its purpose in addition to acting as a useful discovery metadata directory is to identify where there are significant gaps in the data, by type, precision and quantity, in the context of Africa’s relevant geological belts and provinces. However, this is predicated on first understanding the geodata requirements of the EI sector in terms of providing a basic level of coverage across the continent and providing useful information to investors around areas of known metallogenic belts and other areas that may be of interest.

In creating this Atlas, the following issues were found:
- That there is considerable variation between countries in terms of the types, quality and resolutions of which data exist.
- In the majority of cases it is difficult and time consuming to discover which data exist and how to make contact with their custodians.
- That many of the indicators of data availability or access paths that are shown on public websites are out of date or unavailable.
- Many historical data, especially maps, are still located in analogue form in the archives of the BGS3, BRGM4 and the Musée royal de l’Afrique centrale, Tervuren, and that for various reasons these are generally only made available for inspection by personal visit.
- Many of the most easily available sources of information are of low resolution and difficult to use, such as the “pdf” images on the EU-ACP web siteiii (which, nevertheless, is an excellent source of information).

3. Africa’s geological belts and provinces

Annex 1a shows the main geological belts and provinces for Africa from various publically available sourcesv, and Annex 1b shows the main areas of extractive activities. Comparison of the two indicates a relatively poor spatial coincidence between regions of extractive activities and the main cratons, although a stronger one with the mobile zones at their margins and younger fold belts. The exception is perhaps the concentration of mining resource activity trending NNE-SSW that parallels and includes much of the East African Rift System, but also extends well beyond it.

A number of factors may explain these discrepancies:
- Geological factors, such as thick cover sequence, making it more challenging and expensive to carry out survey work in some areas.
- The agglomerative effects of known resources attracting detailed exploration in its immediate vicinity rather than in less accessible areas, partly because of perceived risk reduction by investors.
- Existing infrastructure making it more cost effective to operate locally and hence influencing investment decisions to expand there, rather than in geologically more prospective areas but with poorer infrastructure, including of geodata.

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3 British Geological Survey: www.bgs.ac.uk
- Non-geological factors, including legislation, political stability, governance and suchlike, that attract or repel investment in the extractive industries and have a greater influence on operational location than the geological indicators.

Thus it can be inferred that there are areas which are geologically under-explored and potentially prospective that, given better alignment of the geological conditions with non-geological factors, including infrastructure, could be economically viable. These areas do not necessarily lie within nation state boundaries nor, conversely, does the entire nation state always fit within prospective areas. This implies that priority areas for the collection, storage and dissemination of new or improved geodata are likely to lie in trans-national zones, rather than coincide with national boundaries. By overlaying the geological maps (Annex 1a) and the areas of current extractive industry activities (Annex 1b) it is possible to identify five zones (shown at Annex 1c) which contain areas of geologically indicated prospectivity that are in whole or in part currently under explored. These zones could become priority areas for further work, with the caveat that the exact areas will require more detailed studies of the geology and the (actual or potential) infrastructure that may exist, which is beyond the scope of this report. These are labelled as zones 1 through 5 in order of priority (1 is high).

4. Gap Analysis

To identify gaps in the current geodata, the report has focussed on the five zones mentioned above, and in particular on those parts of the zones for which current geodata, as listed in the Atlas, and principally of large scale geological maps and airborne geophysics, are still poor or are only now emerging from recent data acquisition activities there. These include:

Zone 1 - Tanzania\(^5\) (central and north), Kenya (south), Rwanda, DRC (north-east), South Sudan (south and west) and CAR (south east)
Zone 2 - Nigeria\(^6\) (south-east), Cameroon, Gabon\(^7\) (north), CAR, South Sudan (north) and Sudan (south)
Zone 3 - Namibia (north), Angola (south), Zambia, Zimbabwe (north) and Malawi
Zone 4 - CAR, Chad and Niger (east)
Zone 5 - Ghana (east), Benin, Nigeria (west), Burkina Faso and Mali (east)

Other significant gaps in (public) geodata exist for much of North Africa, especially Algeria, Libya and Egypt, which are all areas of hydrocarbon potential including potentially large volumes of shale gas in Libya and the Western Deserts, and for the offshore continental margins of most of the Continent.

\(^5\) To be addressed in current World Bank funded project activities.
\(^6\) Partly addressed in recent World Bank funded project activities but geodata not yet widely available.
\(^7\) Partly addressed in recent EU-SYSMIN funded project activities but geodata not yet widely available.
5. Industry Survey

A survey of the extractive industry sector has been carried out with the aim of understanding more fully its requirements for geodata by type, resolution, quality, format and accessibility according to different sub-sectors, in making their investment decisions; current and required levels of service provision from the custodians of geodata; price sensitivity according to type and delivery of geodata.

The survey questions are reproduced at Annex 2a. It received a good response with over 100 country-activity returns (from 71 discrete respondents) representing a good range of industry players including some of the World’s largest mining and exploration companies through to juniors and those in the consultancy and other related service areas. In many cases the questionnaire was answered by senior decision makers, who were approached individually by name, based on personal contacts. It is therefore possible to regard the survey as having a high input quality and being statistically significant across the sub-sectors and the region, relative to the levels of type operation (in other words, whilst there are far more responses from the mining industry compared to oil and gas, this reflects the overall presence of those sub-sectors in Africa).

The survey results are shown in Annex 2b with their implications discussed here.

The survey makes it clear that the industry feels it is currently poorly served with geodata by the national geological surveys of the countries in which they operate. Some of the textural responses, not reproduced in this report for reasons of confidentiality, are particularly critical of the poor service quality, inefficiency and, in some cases, corrupt practices faced by the industry when trying to obtain geodata from national geological surveys.

More than half the industry has returned verdicts of poor to unacceptable for access, quality and appropriateness of geodata held by national geological surveys in Africa. Most countries are criticised, with a few exceptions; Namibia and Botswana come out well:

“Namibia. An exception in African terms. Data easily accessible and cheaply available”.
“Botswana - open data policy. Working on getting more organized. Much available at no cost”

Most countries are described as having under-performing geological surveys, poor or non-existent systems for data retrieval, fragmented databases, poor quality, old and missing data. In most cases it is necessary to make personal visits to the national geological surveys, which may act as a deterrent in making investment decisions in those countries. There are no reported examples of efficient data distribution over emails or web based servers.

Of some concern from the survey is that many of the countries which have recently received large investments in collecting, storing and disseminating geodata as a result of projects funded through the World Bank or the European Union do not necessarily come out significantly better than those countries which have not had such investments. This reflects a somewhat subjective view from the industry and may be linked to the lack of post-project funding to maintain the databases and retain the staff skills built up during the funded projects. Thus a service provision from a country’s geological survey may improve, much to the delight of the industry, and then fall back after the project, but not to its original basic levels, which causes disappointment and frustration in the industry which has become used to a higher level of service. This is apparent, for example, in Mozambique where the computers hosting the geodata acquired during the World Bank/NDF funded projects from 2002 to 2007, are now ageing and beginning to malfunction, despite the best efforts of the staff there to keep them going, with a resultant negative impact on data accessibility".
However, the provision of geodata for Mozambique still remains far superior to what was available before the World Bank funded projects there.

Looking at the types of geodata required by the industry to support their decisions and operations, it is clear that geological maps, in general, are the first choice need for 41% of respondents, with airborne geophysical data the next most required first choice data type with 18%. By combining first and second choice requirements, airborne geophysics leads with 61% of respondents and geological maps attract 55% of the combined scores. Other types of data appear to be relatively unimportant in comparison. There is no great difference in the requirements of the mining and oil/gas sub-sectors; both give highest priority to airborne geophysics and geological maps. The oil and gas sub-sector understandably has no requirement for mineral prospectivity reports and (surface) geochemistry.

Examining in more detail the specific requirements of the industry as a whole, the 16 categories of geodata defined in the questionnaire have been ranked in decreasing order of importance to the industry, at table 1 (section 8). Airborne geophysical data and large scale vector digital geological maps are in the numbers 1 and 3 positions, with geological maps at 1:1m (or smaller scales) being the least required, in positions 15 (printed) and 16 (vector). The lack of interest by the industry in small scale maps contrasts with the high priority often given to these scales of mapping by some geological surveys and international publicly funded bodies.

### 6. Public vs. Private Sector Responsibility for Geodata

The six core enterprise processes in exploration and mining are normally taken to be - Discover, Establish, Exploit, Beneficiate, Sell, and Rehabilitate. The Discovery phase is sub divided into (i) prospect / explore (ii) assess resource (iii) examine production options (iv) develop business plan and (v) acquire, but what is not generally made clear in such value chain analysis is the extent to which the public sector, normally through the national geological survey, has responsibility for exploration and discovery before this becomes a matter for the exploration company.

In general, the costs of exploration, which include the acquisition and processing of geodata, rise with time as the target area is reduced, however it is observed that the responsibility handover point (from public to private sector) relative to this varies according to level of economic development of the country and the business sub-sector, as shown schematically in figure 1. Superimposed on this diagram is a table showing the main categories of geodata, derived from table 1. It is seen that their distribution is non-linear across the horizontal axis, and in particular that the shaded (grey) area can fall into either the public or private side of the responsibility markers (crossover points), depending on the geographical circumstances and sub-sector. For much of Africa, the production of large scale maps remains a requirement for public geodata in the minerals sector, but not so in the oil and gas sector, whilst this scale of mapping is often seen as the responsibility of the private sector in developed economies.

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8 Here meaning 1:100 000 or 1:200 000 scales. For the avoidance of doubt, the convention is used that a large scale map is more detailed than a small scale map, eg 1:50 000 is “large scale” and 1:1 000 000 is “small scale”.

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### Types of geodata (refer also to Table 1)

<table>
<thead>
<tr>
<th>Types of geodata</th>
<th>Regional scale prospectivity brochures / desk-study</th>
<th>Small scale maps</th>
<th>Medium scale maps; airborne surveys</th>
<th>Large scale maps; geochemical surveys</th>
<th>Target scale minex surveys</th>
</tr>
</thead>
</table>

**Figure 1** – public – private responsibility cross over points
In discussion with EI companies and national geological surveys, a number of reasons were identified for these observations, although the situation varies considerably between states:

- The marked difference between the oil and gas (O&G) and mining sub-sectors may be explained, in part, by the service offerings of national geological surveys. Historically, these focussed on mining, originating in the days before oil was a significant global commodity. The model left behind in Africa by the BGS, BRGM and others is of geological surveys that focussed on regional scale geological mapping aimed at mineral reconnaissance. Most African geological surveys are little changed today from that original model, and are ill adapted to the needs of oil and gas development, which often is left to the companies themselves, and sometimes have responsibility of a different government ministry.

- O&G exploration is often offshore, for which there is rarely much publicly available data. Thus O&G companies, or those servicing them, have developed proprietary exploration capacity and capabilities that they can re-use onshore, with less dependence on publicly available data. Concomitantly, there is a developed business sector that acquires and sells specialist and high-value, confidential geodata commercially (“spec-data”) into the O&G market with little coordination with publicly available geodata.

- The mining sector is generally more fragmented than the O&G sector, involving a greater dependence on a “food chain” of junior exploration companies (sometimes little more than one-person operations) trading their concessions upwards to larger exploration companies that in turn sell to junior and later to major mining houses. The exploration baseline therefore depends more heavily on the availability of public geodata – which can be seen as the base layer of the mining food chain, without which the larger players would not easily exist. This compares with O&G companies that are generally larger and more “top down” (or vertically integrated) in that an existing player carries out or sub-contracts activities in new regions, with a greater willingness and ability to keep the regional exploration work in-house, other than fulfilling its obligations under the terms of its licence to lodge data confidentially with a government regulator.

- The principal difference in the crossover position between Africa (greater dependence on public geodata) and the more mature mining economies of Australia, Canada and suchlike (lesser dependence on public geodata), is probably due to the more dominant presence of mid-cap and major companies in the latter, where the political and legislative risks are lower. These have a greater willingness, and ability, to invest their own funds to acquire relevant geodata quickly rather than to wait for them to become publicly available.

Conclusions from the industry survey, which feed into the recommendations, include:

- That currently available public geodata are not necessarily of the type most required by the EI sector which in some cases is able, and prefers, to acquire its own, even though public geodata may be cheaper or even free of charge. The perceived inadequacies may include quality, resolution, accessibility, and other factors. Smaller players must make do with what is available publicly; larger players are more able to acquire and retain their own data which are not necessarily recycled into public use.

- Investment decisions are not made simply on the availability or otherwise of public geodata – where political and legislative risk is lower, investors may put more resource into data acquisition. Conversely where these risks are higher, investors will depend more on readily available public geodata kick-starting the process, usually through junior companies.

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9 For example, in Botswana the Geological Survey carries out some mineral exploration work itself, whereas in Malawi this is done entirely by the private sector.
7. Cost benefit of geodata

Based on published budgets for geothematic mapping in Africa funded by the World Bank, DfID and under the EU SYSMIN programmes during the last decade, it is possible to estimate the approximate average cost of acquisition of various types of geodata. These are shown in the following chart (figure 2), noting the caveats\(^\text{10}\).

![Figure 2: cost of data acquisition in US$ per km\(^2\)](image)

From the industry survey, it is clear that geological mapping at 1:200 000 scales or larger, and airborne geophysical survey data at 400m line spacing or closer, are the priorities for publicly available geodata in the context of meeting industry need, whilst the lower cost desk updates are useful in investment selection and the highest cost minex surveys are normally carried out by the companies outside of the public domain.

The vexed question of the return-on-spend for public geodata has been attempted by others over many years. Reedman et al\(^\text{vii}\) argue that the economic gain from improved public geodata in a number of case studies ranges from tens to thousands of times the cost, as well as providing other benefits such as reduced risk from natural hazards and access to new supplies of groundwater. However none of these studies can really link cause and effect or address what might have happened anyway, as a result of commodity prices, political changes or legislative improvement. As the oil and gas sector is less dependent on public geodata it is likely to make its investment decisions around many factors, of which the prior availability of public geodata is relatively minor. Mining, especially in Africa, however, depends more on good quality public geodata stimulating junior exploration with a much later stage handover point to the private sector.

EI activities in some countries have grown rapidly following the availability of new public geodata, partly as a result of capacity building and survey programmes funded by the World Bank or other aid

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\(^{10}\) Acquisition costs only – including local and expatriate inputs, logistics and processing but excluding costs associated with database design and building, computers and other fixed assets, and training. All categories are at typical survey / study definitions, but vary between project / country activity. Typical map scales in these projects has been 1:250 000 to 1:100 000; typical airborne geophysical surveys have flown at 400m line spacing with magnetic and radiometric sensors. Desk updates include production of mineral potential brochures and limited ground-truthing fieldwork. Minex surveys are generally carried out by companies for their own use, and the costs are shown here for comparison purposes only.
agencies. There is evidence for this in Mozambique as measured by the growth in applications for exploration licences from 2006 onwards which coincided with the release of new geodata from the World Bank/NDF funded projects in that country, although this may now have slowed. Anecdotally, there has been a similar increase in mining exploration activities in Namibia and Mauritania following the release there of new geodata; in the case of Mauritania this also coincides with offshore oil and gas exploration driven more by commodity price and technology improvements rather than any new geodata. Conversely, following the release of geodata from the World Bank funded work in northern Zambia in the late 1990s, there was a decline in mining activity in the Copper Belt, with very little new exploration and closure of existing mines, largely resulting from falling commodity prices (a situation since reversed with the influx of new investment into the region). In the case of Nigeria, problems of disseminating data following their World Bank funded projects are inhibiting new investments in the mining sector. Zimbabwe has seen an exodus of exploration investment since the 1990s even though reasonably good public geodata were available at the time, as a result of political instability. The relatively low cost option of a desk study of pre-existing data to re-release in digital form, with limited field work, accompanied by simple mineral prospectivity brochures, is known to have attracted investment into Malawi and South Sudan, but probably at a lower level than might be the case if appropriate, modern, public geodata were available.

It is therefore not easy to separate the availability of good geodata from other factors in influencing investment decisions, but it is likely that its absence acts as a disincentive to invest especially in mineral exploration in Africa when the public to private hand over point occurs later in the value chain. The rise in exploration licences in Mozambique from 2005 to 2009 follows the release of high quality geodata, but also corresponds with an upturn in global exploration as illustrated in figure 3. The important point here is that without the new geodata, Mozambique would probably not have benefitted from the cyclic upturn of global activity, that is, some of the exploration dollars would probably have gone elsewhere.

![Figure 3 - cycles of exploration](image-url)
8. Technical aspects of geodata

This section notes the types of geodata and scales required for investment decisions and exploration activities, across industry sub-sectors, based on the industry survey. Table 1 shows in descending order of perceived importance and value to the industry, the various types of geodata normally available.

<table>
<thead>
<tr>
<th>Rank order</th>
<th>Type of geodata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regional / country-wide processed airborne geophysical data (mag, radiometric, e-m) at ~400m line spacing or closer</td>
</tr>
<tr>
<td>2</td>
<td>Regional scale mineral occurrence maps</td>
</tr>
<tr>
<td>3</td>
<td>Geological maps in vector digital (suitable for a GIS) covering most or all the country at a scale of 1:200,000 or larger</td>
</tr>
<tr>
<td>4</td>
<td>Topographic data / maps</td>
</tr>
<tr>
<td>5</td>
<td>Supporting reports / memoirs / published papers</td>
</tr>
<tr>
<td>6</td>
<td>Geological maps (copies or scans of printed maps) covering most or all the country at a scale of 1:200,000 or larger</td>
</tr>
<tr>
<td>7</td>
<td>Cadastral maps / data</td>
</tr>
<tr>
<td>8</td>
<td>Mineral prospectivity summary brochures / booklets</td>
</tr>
<tr>
<td>9</td>
<td>Interpretations of airborne geophysical survey data</td>
</tr>
<tr>
<td>10</td>
<td>Regional scale metallogenic maps</td>
</tr>
<tr>
<td>11</td>
<td>Regional scale tectonic maps</td>
</tr>
<tr>
<td>12</td>
<td>Regional scale geochemical survey results at density of ~1 sample per 10 sq km</td>
</tr>
<tr>
<td>12</td>
<td>Geological maps (copies or scans of printed maps) covering most or all the country at a scale of 1:1 million or smaller</td>
</tr>
<tr>
<td>12</td>
<td>Geological maps in vector digital (suitable for a GIS) covering most or all the country at a scale of 1:1m or smaller</td>
</tr>
</tbody>
</table>

Table 1: Overall ranking in decreasing order of importance to the EI sector of the types of geodata used for investment decisions and exploration activities across the different types of respondents

It should be noted that although currently providing geodata at scales that have a low priority for meeting industry needs, initiatives such as OneGeology, EuroGeoSurveys-AEGOS and CGMW provide an important platform for further cooperation and development and for further work focussed on the extractive industries.

8.1 Minimal/optimal scale of geodata for each purpose

Based on the industry survey and other discussions with the EI sector, early stage interest in a country (table 2) is often based on easily available compilations of existing information, exemplified by the prospectivity brochures produced for Malawi and South Sudan, published articles in trade magazines or background briefs carried out by company geologists. These are usually relatively low cost re-workings of existing geodata, interpreted in the modern context, aimed at board-room level decision making at the country level, and include whatever geodata are readily available in the public domain. Accessibility is more important than scale. In the case of Malawi, the compilers were fortunate to obtain a digital copy of low-resolution (by modern standards) airborne geophysical raw data which were re-processed and enhanced, thus adding more value to the product than, say, a more recent but less available dataset. Regional scale mineral occurrence maps further reinforce
investment decisions in the mining sector. This emphasises the need for easy access to even outdated maps and other data, including those stored in the archives of several European geological surveys.

After country specific investment decisions are taken, exploration work (Table 2) requires relatively large scale/high resolution geological maps and airborne geophysical data at 1:200 000 (minimal) / 1:100 000 (optimal) and 800 m (minimal) / 400 m (optimal) line spacing respectively. It is important to note that vector digital data are preferred, for direct input into GIS. The scale is therefore less significant than the quality/resolution. Exploration activities also benefit greatly from access to memoirs, reports and published papers, including core logs, samples and other materials. In general, the oil and gas sector is more willing to obtain its own exploration data, principally high resolution gravity and seismic surveys, to supplement publicly available products. Accordingly, there is no absolute preferred scale but an accepted minimum one depending on the sector, discipline and aim of the survey.

<table>
<thead>
<tr>
<th>Board room decision making</th>
<th>Exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mining</td>
</tr>
<tr>
<td>Geothematic Maps</td>
<td>Compilations of geological and metalogenic maps at 1:500 000 scale or smaller</td>
</tr>
<tr>
<td>Airborne geophysics</td>
<td>Regional picture</td>
</tr>
<tr>
<td>Geochemistry</td>
<td></td>
</tr>
<tr>
<td>Reports, papers and logs</td>
<td>✔</td>
</tr>
<tr>
<td>Physical samples</td>
<td>✔</td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – types and scales of geodata required at different stages of the early investment cycle

8.2 Amount of interpretation

All geodata involve some degree of interpretation – a geological map is itself an interpretation of sparse observations and an understanding of geological processes. Airborne geophysical data must be processed to be meaningful, and may be further interpreted to reveal geological structures. Satellite images need to be processed, interpreted and, usually, ground-truthed, before they are a useful indicator of the geology. Geochemical samples are analysed for their constituent elements and the raw data gridded or contoured onto maps to define target anomalies.
It appears that much of the industry prefers to obtain geodata at a relatively low level of interpretation and then to carry out its own studies using in-house expertise and facilities. The amount of interpretation required is also a function of the size and sophistication of the exploration company – generally the larger organisations are better able to carry out interpretations than the national geological surveys, whilst the juniors depend more on the geodata being pre-interpreted by the geological surveys.

In general terms, the industry welcomes good quality, open format, digital geological maps accompanied by detailed field notes and reports, but is less interested in more academically inspired memoirs and published papers. It wants processed, but not necessarily interpreted, airborne geophysical data and satellite images, in digital open formats for subsequent in-house refining. Of particular use is sub-surface depth control information, from boreholes or trenches, that enable a company to build reliable 3D models using sophisticated software such as Vulcan™ or Datamine™.

**8.3 Criteria for prioritising new geodata**

Based on input from the El sector, and taking into account existing and available geodata, it is possible to suggest prioritisation for new geodata types, although this varies slightly according to industry sub-sector and between countries. The generalised sequence of needs, from early stage investment decision making (stage 1) through to active exploration (stage 4) is:

**Stage 1** - A compilation of existing geological, mineral occurrence and geochemical maps and reports, with reprocessing of any existing airborne geophysics, to produce resource prospectivity reports or booklets, similar to those publicly available for Malawi and South Sudan, but with the caveat of covering zones or corridors of interest rather than being confined within national borders. These products are relatively fast and cheap to produce, provided that their compliers have good access to a range of existing geodata, preferably in digital form. They are aimed mainly at the investment promotion and board level investment decision phases.

**Stage 2** – Noting that many of the older/colonial era geological maps are accurate in terms of line-work and lithological descriptions, although out of date in terms of their geological interpretation, where these are available they can often be digitised and re-worked with minimal ground-truthing to produce meaningful and useful new geodata at relatively large scales (high resolution), suitable for input to company GIS. This is a fairly low cost and rapid activity that can cover trans-national zones or corridors, and can additionally be supplemented by (new) satellite imagery. This approach has not, generally, been adopted by the country specific programmes partly because it depends on expertise and technology not usually available in the national geological surveys of developing economies and partly because of some vested interests, on the part of both the supply side and beneficiaries, of carrying out extensive new field based campaigns, which are considerably more expensive and time consuming to deliver and beg the question of cost-benefit of new fieldwork against re-interpreting existing data with minimal ground trothing and, perhaps, some new geochronology.

**Stage 3** – The greatest value-for-money in terms of industry benefit is from new, high resolution airborne geophysical data, principally of magnetic and radiometric for mineral exploration and gravity for oil and gas. Where country/region/zone/corridor-wide coverage is prohibitively expensive, smaller target areas can be identified from the outputs of stage 2, above.

**Stage 4** – There is a clear industry requirement to obtain high resolution digital geological maps in areas of interest – these areas should be identified from stages 2 and 3 leading to subsequent...
localised geological mapping and geochemical survey at scales of 1:100 000 - 1:50 000, limited to prospective areas along infrastructure corridors.

8.4 Average cost of achieving new geodata coverage

Most World Bank or EU supported geological programmes in Africa have included many costs not directly linked to achieving new geodata coverage, but based on the important need to build local capacity and re-equip public infrastructure. Examples of this include new buildings, vehicles, laboratories, computers and staff training. Inevitably this favours a country level development of geodata, rather than zone/corridor approaches, but risks producing geodata for areas of low inherent prospectivity, in the interests of obtaining national coverage and maximising use of the new facilities.

Figure 2 reflects the cost of acquisition of various types of geodata in recent World Bank / EU / DfID programmes, based on the approaches taken in those projects, but excluding indirect costs such as capacity building. By combining these costs with the stages described in section 8.2, a combined cost per km² for a range of development scenarios can be derived. For example, in a scenario that first considers 1000 units of area for stage 1 review (investment decision making) with a subsequent zoom in on 100 units of area for stage 2 (re-working of pre-existing maps with new ground-truthing) followed by a selection of 10 units of area for stage 3 work (airborne geophysics) leading to 1 unit of area for stage 4 (detailed geological survey), the combined cost for the original 1000 units of area is $4.3 per km². The table below shows how these costs vary across different “zooming in” ratios. The choice of zoom ratio will depend on potential prospectivity – ratio A is more suitable for areas with low potential and D for areas with high potential.

<table>
<thead>
<tr>
<th>Number of units of area in combination</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Stage 2</td>
<td>100</td>
<td>200</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>Stage 3</td>
<td>10</td>
<td>40</td>
<td>160</td>
<td>640</td>
</tr>
<tr>
<td>Stage 4</td>
<td>1</td>
<td>8</td>
<td>64</td>
<td>512</td>
</tr>
<tr>
<td>Total cost per km²</td>
<td>$4.3</td>
<td>$10.7</td>
<td>$37.8</td>
<td>$162.0</td>
</tr>
</tbody>
</table>

9. Institutional aspects of geodata

9.1 Warehousing and dissemination

Earlier parts of this report refer to the difficulties faced by the industry in accessing geodata, and to the loss of geodata in the years following an institutional strengthening programme. There are a number of issues to be addressed:

- Poor service functions in many African geological surveys, - the industry survey revealed widespread dissatisfaction with obtaining geodata from many national geological surveys. The surveys may be remote from the users’ locations, either within the country or internationally. They are frequently underfunded, with inadequate facilities for geodata warehousing (both analogue and digital) and lack reprographic equipment. Staff are often poorly paid, opening up the possibility of corrupt practices. Examples have been quoted of unique copies of reports
being sold for personal gain, or geodata being made available only on payment of relatively large amounts of un-receipted cash.

- The problem of underfunding is often compounded after the end of an externally funded institutional strengthening project when equipment bought and set up by the project is no longer maintained and falls into disrepair, and/or the personnel trained by the project leave the organisation for better paid jobs elsewhere.

- The industry survey did not reveal any examples in Africa of a geological survey being able to reliably deliver geodata digitally from its web site, and less than 5% of responses can receive geodata reliably by correspondence alone.

- The types of geodata that are currently most easily made available over the internet, typically from web servers supported by multi-national projects, are often those least required by the industry (table 1).

- External archives of geodata, such as map collections held by BGS, BRGM and others, are frequently in analogue form only. Putting aside the not inconsiderable costs of scanning these records to make them available digitally, there are issues such as copyright to be resolved before this can take place. Similar problems of ownership arise for copies of geodata held securely by contractors such as airborne survey companies.

- There is a resistance on behalf of traditional national geological surveys in Africa, and elsewhere, to the concept of “letting go” of geodata on a regional or intercontinental basis, even where this could lead to more effective dissemination services because of cost sharing or higher bandwidth. Data are seen as national assets, to be retained within the country, and as a source of income to the geological survey.

There is a clear need to address these issues if the EI sector is to fully help develop Africa’s natural resource potential. Urgent solutions are needed to find ways of improving the long term storage and dissemination of existing and new geodata.

Few of the concerned parties consider it worthwhile to delay until international data models and standards are finally agreed. Such initiatives tend to be slow, top-down and sometimes fail to deliver any significant practical changes. The EI sector is more interested in having better access to existing geodata now, complete with all their inherent imperfections, rather than perfectly modelled and homogenised data at some indeterminate time in the future.

The challenge is to migrate copies of existing geodata from their dispersed and often poorly organised locations to efficient, high bandwidth web based delivery services capable of taking the geodata directly to the end user. This will require delicate negotiation with current custodians of geodata, many of whom are reluctant to release copies for this purpose, and it will require a business model that both recompenses the current custodians for lost revenue and covers the operational costs of the service without significantly increasing the price of data to end users (the industry survey showed a marked reluctance to pay much more for data than is current practice).

For reasons of cost effectiveness and economies of scale, it is likely that such a service should be run at a single location and probably by a commercial company that specialises in this field. Technical considerations of bandwidth and political neutrality may indicate its location would lie outside Africa.

The principal benefits of an effective dissemination process would be of immediate access by the EI sector, the possibilities of revenue generation from data trading and adding value by combining data sets and, in particular, the transparency created by fair and open access.
However, it is likely that considerable persuasion, and incentive, would be needed to ensure that current custodians of geodata in Africa would agree to participate, even though in most cases it would be in their long term national interest to do so. Incentives might include access to development funds to improve the quality of geodata, whilst disincentives would be that those left behind are less likely to see as much inward investment as those participating. Most probably, discussions on migrating existing geodata need to be held at the Ministry level, rather than with the national geological survey organisations themselves, which are perhaps more focussed on outputs than on outcomes.

There are likely to be commercial companies willing to invest in such web based distribution portals or services and organisations such as the World Bank could use their good offices to support such initiatives. Such support could include set-up funding as well as coordination and monitoring activities.

The matter of participation is more easily resolved for future geodata collecting projects funded by development agencies; it is a matter of making the effective long term storage and dissemination of data a pre-condition of the award or loan, and of ensuring that sufficient funding is in place after the project concludes, perhaps through a trust fund, to enable it.

9.2 Regional or country approach

Implicit in the above is that existing geodata are grouped at the level of individual countries or, in the case of small scale maps, for multiple countries making up a geographic region (such as the SADC map, *op cit*). Areas of interest to the EI sector are often in trans-national corridors, and it has been shown that gaps in the current provision of geodata include priority zones for new work that extend over national boundaries. This raises the challenge of geodata integration and homogenisation.

Whilst it is ideally the case that all the geodata for a resource corridor are fully integrated, seamlessly edged matched and with consistent scales, legends, codes and such like, this is an unrealistic ambition in the near future. This is not only because of the large amount of work, and cost, of reaching agreement between the parties on standards, but because implementing those standards usually involves re-interpreting and verifying the geology.

The problem is not so acute in the case of airborne geophysics whose data are usually collected and processed to international proprietary standards maintained by the commercial operators.

Whilst for future work, trans-national standards can be adopted, for existing geodata the evidence from the EI sector is that the inconsistencies are not critical – the industry prefers to have access to imperfect geodata immediately rather than improved products later. What matters is having easy access to all the geodata pertaining to a relevant area of interest, whether that is within a country or across several countries, from a single source, even though the data may arrive in different styles and formats.
9.3 Expertise requirements

There is an asymmetry in human capacity in the ways that mineral rich countries make available geodata. In Canada, or Australia, for example, there are well informed resident district geologists who have a deep understanding of the relevance and implications of the geodata, and are able to advise the industry usefully, even where geodata are in short supply or out of date. In Africa, this level of expertise is rarer; therefore it is more important that the geodata are easily available, of high quality and better able to be self-explanatory. The main expertise required in Africa at the present time is thus in the context of data warehousing and dissemination. It will take some considerable time for Africa to build up a critical mass of resident, experienced district geologists who can compensate for geodata deficiencies.

A web delivered “one-stop-shop” or portal approach to trans-national geodata requires expertise at different levels:
- The largest part of the effort, by far, is in the preparation, labelling and scanning of maps and documents at the current custodians’ premises. This is labour intensive but does not require either a great level of expertise or expensive equipment.
- Integrating the disparate inputs into a spatially or keyword searchable data bank is rather more complicated, although well supported by many standard software tools. This can be carried out either at the national or the trans-national scales, depending on available expertise.
- Bringing the multiple inputs together into a functioning web delivery system or portal, and enable payments, accounting and revenue distribution, is a highly skilled business activity and one that should be awarded to a professional organisation with a successful track record in that field.

The level of expertise required to acquire new geodata will normally extend beyond what is locally available, except in certain countries, such as South Africa and Namibia. There may be no alternative in the near future to sourcing technical assistance from outside sources to assist with new geological mapping, airborne geophysics, seismic or geochemical surveys and satellite imagery interpretation, provided that such programmes remain firmly linked to capacity building and skills transfer.

9.4 Alternative funding

Various business models can be considered to pay for the warehousing and dissemination of geodata, both existing and newly acquired. Such models are not mutually exclusive. They include:
- A mutually owned commercial service run for profit with dividends returned to the owners of the geodata.
- A privately owned commercial service run for profit with payment returns to the owners of the geodata.
- A subsidised not-for-profit commercial service with payments to the owners of the geodata and subsidies coming from development agencies and/or trade bodies.
- A commercially run “freemium” services in which the raw geodata are provided free, or nearly so, and added value products, which may include corridor integrations, are sold at premium prices.
- There is a growing role of the private sector in acquiring and disseminating geodata. This presents an alternative source of funding for the public good provided due regard is taken of the drivers for private sector funding, such as early access to investment opportunities and conflicts.

11 For example through bodies such as SEAMIC (the South East Africa Mining Information Centre) in Dar es Salaam, and SADC, given sufficient funds and expertise. Development work already accomplished in OneGeology and AEGOS could be leveraged into this process.
of interest are avoided. In some cases it may be possible for a trusted, industry neutral organisation to synthesise private company geodata into regional overviews, without compromising the company advantage. This approach is commonplace in the oil and gas sector in areas such as the North Sea and Australia but has rarely been seen in the mining sector.

10. **Recommendations**

The main recommendations coming out of this report are summarised here, followed by suggested specific actions.

**New geodata**

1. The five zones identified in this Report should be the priority areas for the next stage investments in geodata acquisition, with the caveat that the exact areas will require more detailed studies of the geology and the (actual or potential) infrastructure, which is beyond the scope of this work. These zones are trans-national, which will require careful coordination of activities involving several nation states, each of which will need to accept that only part of their landmass may be included in the zones [section 3 and annex 1(c)]

2. The types of geodata to be produced should be phased. Initially, small scale compilations and re-interpretations of existing information aimed at promotion and investment decision making should be produced, followed by medium scale (1:250 000) geological maps and high resolution (400m line spacing) airborne geophysical magnetic and radiometric surveys, for early stage mineral exploration (or magnetic and gravity for oil and gas exploration). In this phase, the greatest cost-benefit in geological mapping is likely to come from re-interpretation of existing geodata with limited ground-truthing and some new geochronology as necessary. The final phase should produce large scale (1:100 000 or even 1:50 000) digital geological maps and geochemical surveys but only in prospective areas along infrastructure corridors. [section 8.3].

3. All new geodata should be produced in digital, open format suitable for further interpretation by the companies. Heterogeneity and adherence to standards is less important than the data being released without delay [sections 5, 8.2 and annex 2].

4. As a condition of the development loan or grant, all new geodata should be web enabled and made freely available to everybody – at minimal charge commensurate with covering the costs of dissemination – from high quality, good bandwidth connected web sites run as one-stop-shops by or on behalf of the countries involved [sections 9.1, 9.2]

5. A business model should be established whereby the long term costs of data maintenance and dissemination may be sustained, post-project [section 9.4]

6. New development projects should avoid unnecessary and potentially expensive systematic ground coverage. Instead they should focus on relevant geodata acquisition and management in appropriate areas using minimal expatriate expertise to build local skills. Trans-national regional approaches to knowledge and skills pooling should be encouraged and facilitated. It is important to ensure wider stakeholder involvement in project design so that private sector interests are incorporated and maximise outcomes rather than outputs [sections 5, 9.1, 9.3]
Existing geodata –

7. Large scale holders of African geodata such as the BGS, BRGM and MRAC should be supported to scan and make freely available on their web sites, and elsewhere, as much as possible of their relevant geodata assets, addressing issues of copyright in pragmatic ways. Priority should be given to scanning and making available existing data “as is” without waiting for agreements on standards, inter-operability and suchlike [sections 2, 8.1, 9.1].

8. Negotiations should begin with African countries, at Ministry levels, with a view to those countries scanning and making freely available for web access existing geodata, including but not limited to maps, open-file reports, borehole logs, geochemistry and geophysical surveys. A business model should be developed to compensate countries for any minor loss of income from current sales of data and financial assistance sought to fund the costs of indexing and scanning [section 9.1].

9. Where geodata have been lost, every effort should be made to recover them, at cost if necessary, from archived copies that may be held by the original contractors or consultants involved [sections 2, 9.1]

Other:-

10. The trend of the private sector moving into the space that more traditionally has been occupied by the development agencies should be encouraged and attempts made to converge its activities with those of publicly funded bodies in the overall interests of the beneficiary nations, provided this does not damage transparency and good practice. Similarly, encouragement should be applied to the sharing of data between the oil and gas sub sector and the wider EI community, and vice versa, across the public – private boundaries [section 9.4].

10.1 Next Steps / Follow-up Work

1. To discuss with the main interested parties, specifically BGS, BRGM, MRAC and EuroGeoSurveys12, to set up projects that place all their archived African geodata on the web, where they will be freely available, with minimal delay (and hence with minimal preparation and conditioning of the data), including the costs of obtaining legal opinion on solutions to problems of copyright of those data. Cognisance will need to be taken of the need for a “politically neutral” and preferably proven, commercial operator of the web delivery service. Progress to date in OneGeology and AEGOS should be used where appropriate, including the migration of OneGeology protocols as necessary. It is likely that a detailed scoping study will be required to define the project parameters and estimate costs.

2. To discuss with private providers the costs and requirements to take forwards into the public domain existing prototype web portals serving African geophysical and other geodata.

12 EuroGeoSurveys can act as an intermediary with all the European geological surveys that may hold African geodata and with the European Union as a potential funding agency.
3. To work with a number of African countries’ mining ministries and/or geological surveys to migrate geodata that have been recently acquired through World Bank or other development projects, and that are at risk of post-project degradation, to a commercially operated shadow server, and to develop appropriate business models to recompense the donor geological survey organisations for any loss of income. It is likely that a detailed scoping study will be required to define the project parameters and estimate costs.

4. To refine the five priority zones for further geodata acquisition based on more detailed studies of the regional geology, existing or planned infrastructure, human capital, legislative and governance environments and all other relevant factors, as inputs to the next rounds of development funding. Planning to also take note of the recommendations of this report, particularly with regard to stakeholder involvement, phased approach to geodata acquisition and the different public-private geodata cross over points relevant to the situation.
Annex 1

(a) Geological belts and provinces

Simplified Pan African Belts / Cratons
Map of the bedrock geology of Africa

(b) Major metallogenic zones and petroleum basins
(c) Priority zones for new or improved geodata aimed at mineral exploration

The zones have been delineated by overlaying areas of craton boundaries, mobile zones and younger fold belts (taken to be proxies for green fields mineral prospectivity) with areas of paucity of modern, digital geodata (derived from the Atlas), excluding areas already well known to the mining industry through current exploration or extractive activities, for which good geodata are likely to exist, and extending these into contiguous rectangles. It does not imply that every part of each rectangle satisfies these criteria, nor are there no areas outside of the rectangles worthy of future investment in geodata acquisition. Further work is required to identify, within each zone, local factors such as national policies and infrastructure corridors, as well as more detailed studies of the geology, that are likely to refine the exact areas for priority attention. These rectangles are likely to contain areas having the greatest economic return from new investments in geodata.
Annex 2 : Industry Survey - Geodata Public Information (GPI)

(a) Questionnaire

Please tell us about your Company (all information is confidential)
Name
Company
Address 1
Address 2
City
Email Address

Is your main business (mark all that apply)
mining
oil and gas
exploration
consultancy
other

Please show in which countries in Africa you operate
Algeria
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde
Central African Republic
Chad
Comoros
Cote d'Ivoire
Democratic Republic of the Congo
Djibouti
Egypt
Equatorial Guinea
Eritrea
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Libya
Madagascar
Malawi
Mali
Mauritania
Mauritius
Morocco
Mozambique
Namibia
Niger
Nigeria
Republic of Congo
Rwanda
Sao Tome and Principe
Seychelles
Sierra Leone
Somalia
South Africa
Sudan, Republic of (North)
Sudan (South)
Swaziland
Tanzania
Togo
Tunisia
Uganda
Zambia
Zimbabwe
Others
None in Africa (please fast forward to end of Survey)

In general terms (not country specific) how do you rate data obtained from the national geological surveys of the countries in which you operate? Please give an "average" perception - later questions will focus on individual countries.

<table>
<thead>
<tr>
<th></th>
<th>unacceptable</th>
<th>poor</th>
<th>reasonable</th>
<th>good</th>
<th>excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ease of access</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>quality</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>price (value for money)</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>appropriate to your needs</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

The next set of questions asks you about the types of geodata public information (GPI) you require. If you operate in more than one African country, please respond with your "average" requirement - later questions will focus on individual countries. Please show below your GPI requirements.

<table>
<thead>
<tr>
<th></th>
<th>not interested</th>
<th>limited value</th>
<th>useful</th>
<th>highly desirable</th>
<th>essential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological maps (copies or scans of printed maps) covering most or all the country at a scale of 1:200,000 or better</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Geological maps in vector digital (suitable for a GIS) covering most or all the country at a scale of 1:200,000 or better</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Geological maps (copies or scans of printed maps) covering most or all the country at a scale of 1:1million or worse</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Geological maps in vector digital (suitable for a GIS) covering most or all the country at a scale of 1:1m or worse</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Regional / country-wide processed airborne geophysical data (mag, radiometric, e-m) at ~400m line spacing or better</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
Interpretations of airborne geophysical survey data
Regional scale geochemical survey results at density of ~1 sample per 10 sq km
Interpreted satellite imagery
Regional scale metallogenic maps
Regional scale mineral occurrence maps
Regional scale tectonic maps
Mineral prospectivity summary brochures / booklets
Supporting reports / memoirs / published papers
Hydrogeological maps
Topographic data / maps
Cadastral maps / data

If you had a choice on what types of GPI you could easily obtain from a national geological survey organisation, regardless of price, please rank the list below into your order of preference.

geological maps
geochemical survey data
airborne geophysics
mineral occurrences /
prospectivity summaries
cadastral information

If the policy of the country is to charge for data, please show below the maximum price you would be willing to pay for data, assuming it is of good quality and delivered to you efficiently.

a typical printed geological map at 1:100,000 scale
a vector digital (for loading into a GIS) geological map “sheet” at 1:100,000 scale
processed airborne geophysics (mag, radiometric, e-m) per 100 sq km
interpreted airborne geophysics per 100 sq km
regional scale, multi-element geochemical survey data per 100 sq km
a typical printed report or memoir

In general terms, if the data listed in the previous question could be made available to you instantly, on-line (for example from a subscription server delivered over the internet) would you be prepared to pay?

no more than the prices already indicated
up to 10 times the prices already indicated
up to 100 times the prices already indicated
In terms of the ease of access to geodata public information from national geological surveys, what is your generalised (average) experience?

<table>
<thead>
<tr>
<th>virtually impossible to get hold of data under any circumstances</th>
<th>very difficult requires personal visit and sometimes inappropriate payments</th>
<th>reasonably easy and correct but only by personal visit</th>
<th>can be obtained reliably by correspondence</th>
<th>excellent access over internet and web site</th>
<th>N/A</th>
</tr>
</thead>
</table>

For each of the African countries in which you operate (if more than 5 please use top 5 only) please comment on your geodata public information requirements and how well or badly these are served by the national geological survey organisation. Your comments will be treated in strict confidence.

Please start each answer with the name of the country.

Country 1
Country 2
Country 3
Country 4
Country 5

**Survey Results**

**Business areas and countries of operation**

The charts in this section show the business sub-sectors and the countries of operation of the respondents. Some operate in more than one country. All the main business sub-sectors and most countries of Africa have been covered.

**Business sub-sectors by percentage of responses:**

![Bar chart showing business sub-sectors](chart.png)
Countries of operation, by percentage of responses:
Geodata from national geological surveys

Overall service levels, value and appropriateness of geodata from national geological surveys:

Specifically on availability of geodata from national geological surveys:
Types of geodata

Rank order preference for types of geodata used to support investment decisions and exploration:

Height of red coloured blocks – percentage of responses putting this type of data as 1\textsuperscript{st} choice
Height of green coloured blocks – percentage of responses putting this type of data as 2\textsuperscript{nd} choice
Height of (dark) blue coloured blocks – percentage of responses putting this type of data as 3\textsuperscript{rd} choice
Height of yellow coloured blocks – percentage of responses putting this type of data as 4\textsuperscript{th} choice
Height of (light) blue coloured blocks – percentage of responses putting this type of data as 5\textsuperscript{th} choice
Price sensitivity of geodata

If the policy of the country is to charge for data, please show below the maximum price you would be willing to pay for data, assuming it is of good quality and delivered to you efficiently.

In general terms, if the data listed in the previous question could be made available to you instantly, on-line (for example from a subscription server delivered over the internet) would you be prepared to pay:

- up to 100 times the prices already indicated
- up to 10 times the prices already indicated
- no more than the prices already indicated
References

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7 Reedman A. J., Calow R., Piper D. P. and Bate D. G. “The value of geoscience information in less developed countries” Research Report CR/02/08, British Geological Survey
8 Duadi F E., Director of the DNG Mozambique, personal communication
10 Sources include a workshop held in Gaborone, Botswana, March 2011, and subsequent interviews, with the EI sector operating in Botswana and neighbouring countries, and a training workshop held at SEAMIC, Tanzania, in 2005
11 2009 Compilation of Geological, Geophysical and Mineral Potential Data of Malawi, Department for International Development, British geological Survey
12 2011 Minerals of the Republic of South Sudan, Grosvenor Investment Corporation, BGS International UK
13 Key, R.M., 2009, personal communication