

## **Metallurgy From Above – A Google Earth Perspective**

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**Abstract** – Google Earth is a piece of software able to display an interactive three-dimensional map of the world, combining aerial and satellite photography with maps, terrain, and user-generated geographical information systems (GIS). Many structural features of the planet, both natural and man-made, are of great interest to the mining and metallurgy field, and in this paper a study is made of the current state of the art of data accessible by Google Earth.

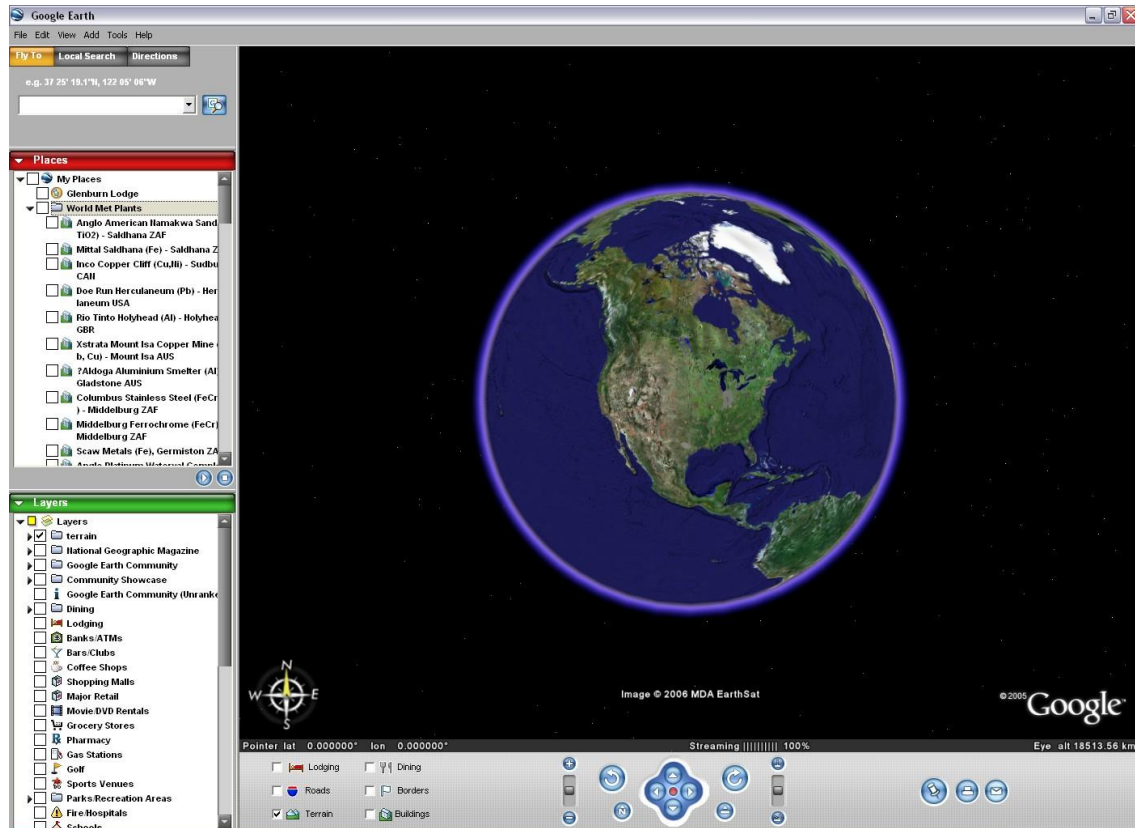
### **INTRODUCTION**

“There is something new: A globe about the size of a grapefruit, a perfectly detailed rendition of Planet Earth, hanging in space at arm’s length in front of his eyes. Hiro has heard about this but never seen it. It is a piece of CIC software called, simply, Earth. It is the user interface that CIC uses to keep track of every bit of spatial information that it owns – all the maps, weather data, architectural plans, and satellite surveillance stuff.”

– *Snow Crash*, Neal Stephenson, ©1992

Perhaps inspired by Stephenson’s concept, Google<sup>1</sup> released the first version of Google Earth<sup>2</sup>, an integrated and extensible geographical information system (GIS) product, in May 2005.

Google Earth provides a three-dimensional interface to a globe of the world (see Figure 1), mapped out using a combination of satellite and aerial photography from a variety of sources. This interface can be used to rotate the globe, zoom in or out on a particular region, tilt and rotate the view, and overlay any number of ‘layers’ on the image to provide extra information.



**Figure 1:** The Google Earth start-up display [Image ©2006 MCA EarthSat]

Covering the globe at moderate to high resolution, much of the imagery is capable of showing interesting details of both metallurgical plants and the geological structures their products originate from.

## **GIS AND GOOGLE EARTH – DEVELOPMENT AND TECHNOLOGY**

From the earliest days of human history, maps have been used to navigate and assimilate information about the planet we live on.

In the 1960s, the concept of integrating many different types of spatial geographic information onto a map image, using computers, was developed.<sup>7</sup> These early prototypes of GIS systems included many of the standard features still seen today, such as information layering, linking of locations with other information databases, and so forth.

With the evolution of modern computer technology and the mass-market usage of the Internet following on from it in the early 1990s, commercial software to perform GIS functions began to rise in popularity. At first extremely costly, and used in niche markets such as oil prospecting, airplane and boat navigation systems, and linked to early implementations of the GPS satellite location system, GIS technology soon began to pervade the consumer consciousness.

The release of the Xerox PARC Map Viewer<sup>8</sup> in 1993 also signalled a change in how geographical information was disseminated. By separating the map

information database from the viewer application, and storing the database at a location on the Internet instead of the user's computer, very large GIS data sets could be provided and maintained with ease, and accessed remotely using the relatively small viewer application.

In 2001, Keyhole Software launched the first version of its Keyhole GIS software. A number of innovations over conventional mapping and GIS applications were pioneered by Keyhole, including using a three-dimensional globe instead of a flat map plane, the provision of moderate to high resolution satellite and aerial photographic images covering the entire planet, and the development of an open mark-up language (Keyhole Markup Language, or KML) which allowed the user to dramatically extend and enhance the software's GIS systems by providing their own data.

Google Incorporated, looking to extend their market involvement after providing definitive Internet search functions during the dot-com boom era, purchased Keyhole Software and the rights to its products in October 2004. After several months of development, Google subsequently launched Google Maps<sup>3</sup> - a novel online mapping program- in February of 2005, and with this experience, reworked the Keyhole GIS viewer into Google Earth, which was launched in May 2005.

### **Technology**

Google Earth functions as an interaction between two discrete entities - the GIS database, and the viewer application - linked by an Internet connection.

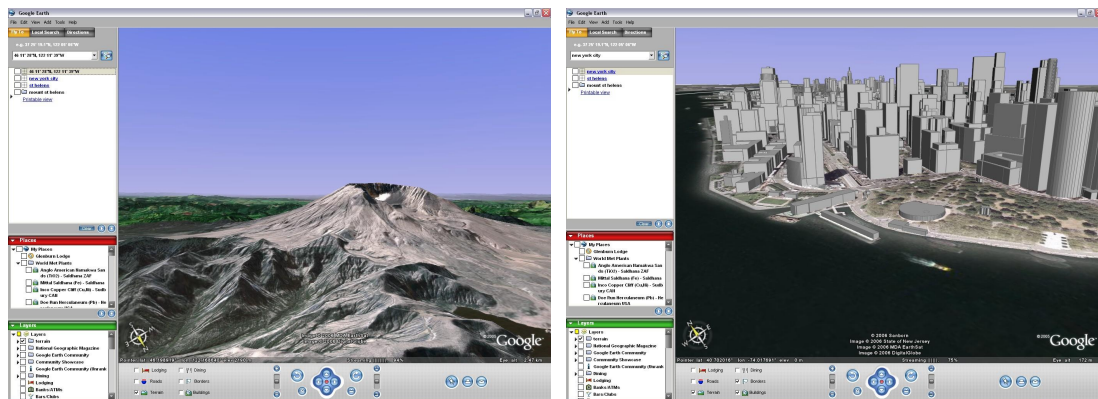
The database is an extension of the collection of imagery amassed by Keyhole Software during their operation. It consists primarily of a wide variety of both satellite (usually lower resolution, but covering larger areas) and aerial (higher resolution, covering localised areas) photography. Imagery of the entire globe is stored on the database server at several levels of detail, with the lower resolution images interpolated progressively from higher resolution ones. At each level of resolution, the surface of the globe is then divided up into small squares, or tiles, each indexed and stored in the database. Other available geographical information, such as elevation above sea level, roads, and country borders, is stored in a similar hierarchical way.

When the view is changed in the viewer application, a request is made to the database. The database is sent the level of detail required (which is linked to the virtual distance of the viewer from the ground), and the area required (which is linked to the field of view). Only the image tiles and other information appropriate for the current view are extracted from the database and sent back to the viewer application via the Internet, thereby minimizing the bandwidth required on the link between the two.

The viewer application renders the data provided to it by the database on a fully three-dimensional globe. The globe surface is approximated by a collection of triangular elements, and the images are draped over this surface

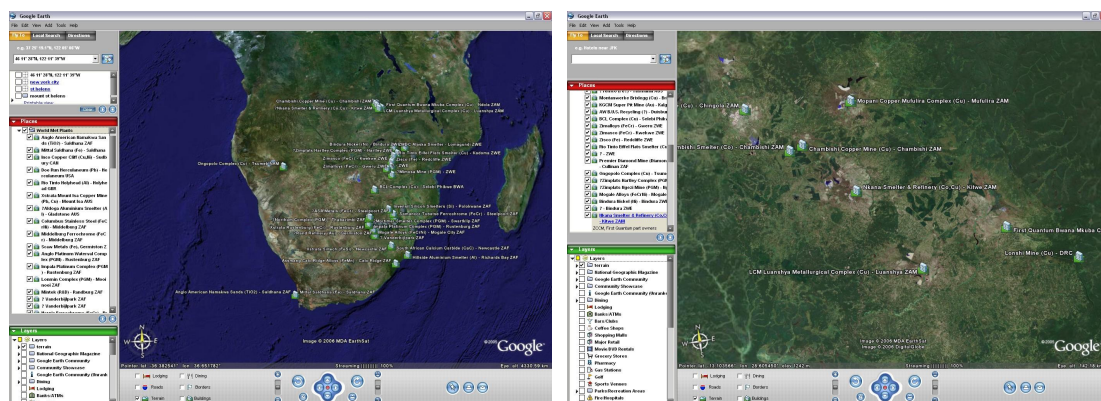
using a process called texture mapping. The rendering of the surfaces and imagery requires a large amount of processing power, and is handled entirely by the graphics card in modern computers.

In addition, the viewer can add layers of GIS information to the globe. Several standard layers are available, and stored in the database along with the photographic imagery. Among these are *terrain*, which raises or lowers the imagery around the point viewed to show the lay of the land, *roads*, which in many first-world cities will overlay street maps and road names on the image, *borders*, which displays national and provincial borders, and *buildings*, which adds 3D models of all buildings in the central business districts of several prominent cities in the USA. Some examples are shown in Figure 2.



**Figure 2:** Google Earth is able to render both terrain (left) and city buildings (right) [Images ©2006 DigitalGlobe, ©2006 MDA EarthSat, ©2006 Sanborn, ©2006 State of New Jersey]

One of Google Earth's most powerful features is the ability to add custom GIS layers created by other users of the software, or even create layers oneself. Google has retained the simple and powerful KML language for use in Google Earth, allowing users to highlight locations and areas and attach to them useful information such as descriptions, statistics, and links to the Internet. A small collection of metallurgical sites in KML format is shown in Figure 3.



**Figure 3:** A KML collection of metallurgical sites in southern Africa (left) and the Zambian copper belt (right) [Images ©2006 DigitalGlobe, ©2006 MDA EarthSat]

## **APPLICATIONS FOR GOOGLE EARTH IN METALLURGY**

### **Site viewing**

Using Google Earth as an accessible, open GIS system permits access to a huge archive of recent photography of geological structures of interest to metallurgists, as well as mine sites and metallurgical processing plants.

For larger sites, even low-resolution coverage is more than sufficient to show details of the site layout and structure, giving the viewer much information about the processes conducted there. The size of open pit mines is clearly visible in the terrain, as are mine dumps, slimes dams, and raw material stockpiles, giving a sense of scale to a particular mine or plant site. In many areas, railway lines and roads can be overlaid on the view, showing supply paths in and around plants.

In areas of high-resolution coverage, individual unit operations such as rotary kilns, furnace buildings, settling tanks, and other equipment, are often visible, allowing correlations to be drawn between a plant flowsheet and its physical layout. Such information could be used effectively as a teaching tool at universities, or by individual sites for induction training of new or relocated staff.

Another possible use is in accelerating preliminary research on green-field sites or potential expansion projects. In Google Earth, physical proximity to human settlements, natural resources, power stations, and ecologically sensitive areas can be determined at a glance either visually, or by overlaying pertinent GIS data sets, allowing quick decisions to be made.

### **Open databases of plant information**

The easy extensibility of the Google Earth KML file format for GIS data suggests another possible use for the application, namely generation of a community-supported GIS data set of metallurgical plant sites around the world.

This data set would potentially include physical location of plants, explanation of the site layout either using area highlighting or verbal description, attached information and statistics such as (among others) products, date commissioned, production capacity, process flowsheet description, links to external websites providing more information, and so forth.

Such a data set could easily be disseminated to users of Google Earth via the Internet, allowing them to both access the existing information, and contribute to and extend it themselves.

There are currently several sources of information for physical location of metallurgical plants available in the open literature.<sup>4,5,6</sup> However, many of these provide only localised or fragmentary information. A consolidated database of spatial information pertinent to metallurgy in general, and

pyrometallurgy specifically, would be of great value as tools like Google Earth mature and become more mainstream.

A simple version of such a database has been tested at Mintek, and found to be very effective in correlating basic information with the plant locations and spatial characteristics immediately visible in Google Earth. A sample of some of the information included in the database may be seen in Table I.

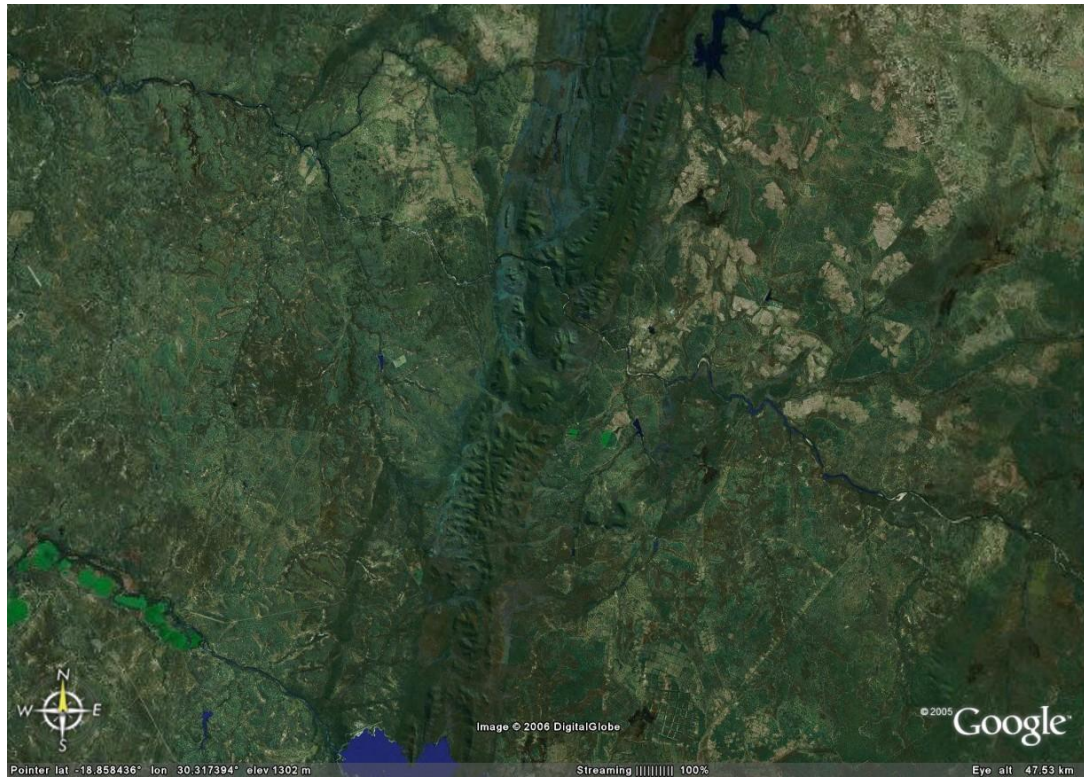
**Table I:** Geographical coordinates of some pyrometallurgical sites around the world

<i>Plant</i>	<i>Location</i>	<i>Latitude</i>	<i>Longitude</i>
Palabora Copper Complex	Phalaborwa, South Africa	23.992°S	31.129°E
Inco Copper Cliff Smelter	Sudbury, Canada	46.479°N	81.054°W
Mogale Alloys Smelter	Mogale City, South Africa	26.131°S	27.755°E
AW B.U.S. Recycling	Duisburg, Germany	57.377°N	6.734°E
Mittal Steel Saldanha Works	Saldanha, South Africa	32.963°S	18.046°E
Namakwa Sands Ilmenite Smelter	Vredenburg, South Africa	32.979°S	18.023°E
BCL Copper Complex	Selebi-Phikwe, Botswana	21.943°S	27.858°E
Mount Isa Metallurgical Complex	Mount Isa, Australia	20.715°S	139.480°E
Kalgoorlie Nickel Smelter	Kalgoorlie, Australia	30.873°S	121.484°E
Hillside Aluminium Smelter	Richards Bay, South Africa	28.765°S	32.029°E
Mozal Aluminium Smelter	Maputo, Mozambique	25.915°S	32.408°E
Doe Run Herculanum (Lead)	Herculanum, USA	38.261°N	90.376°W
Impala Platinum Complex	Rustenburg, South Africa	25.518°S	27.212°E
Anglo Platinum Waterval Smelter	Rustenburg, South Africa	25.669°S	27.323°E
Lonmin Platinum Complex	Rustenburg, South Africa	25.706°S	25.719°E

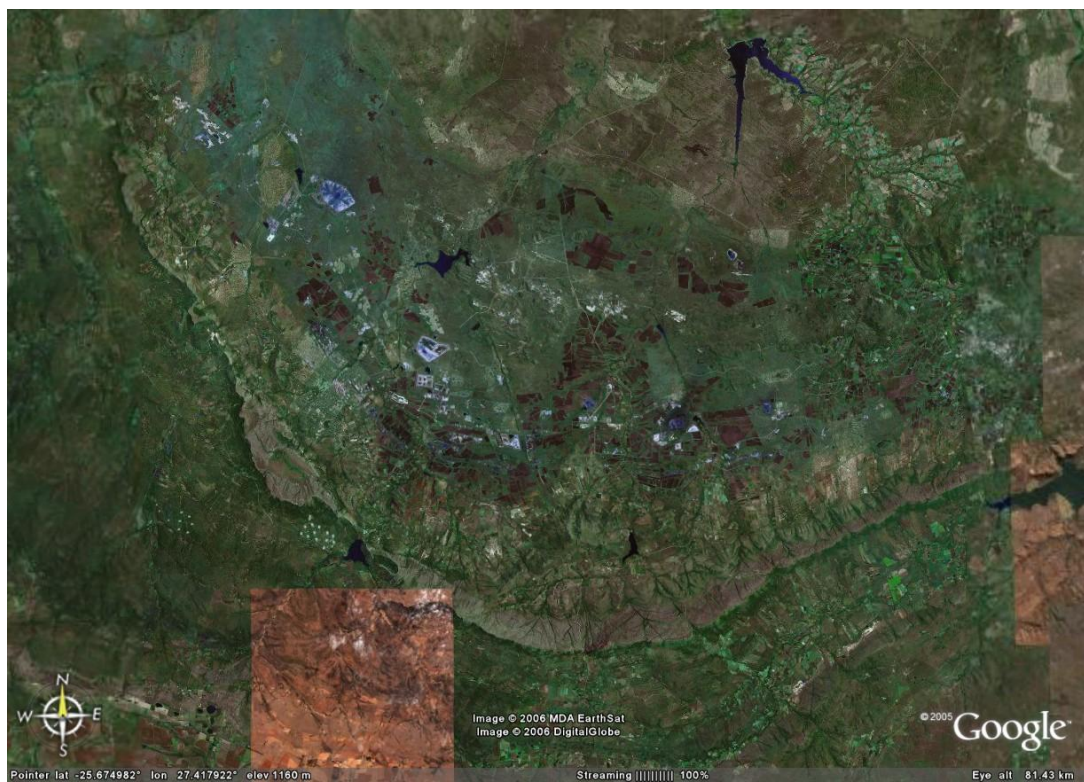


## EXAMPLE IMAGERY

### Geological structures



**Figure 4:** A section of the Great Dyke in Zimbabwe [Image ©2006 DigitalGlobe]



**Figure 5:** The Bushveld Complex west of Johannesburg in South Africa [Image ©2006 MDA EarthSat, ©2006 DigitalGlobe]



## Smelter plants in southern Africa



**Figure 6:** Namakwa Sands ilmenite smelter in Vredenburg, South Africa – furnace building and surroundings [Image ©2006 DigitalGlobe]



**Figure 7:** Mittal Steel Saldanha plant in Saldanha, South Africa [Image ©2006 DigitalGlobe]





**Figure 8:** Mogale Alloys smelter, Mogale City, South Africa [Image ©2006 DigitalGlobe]

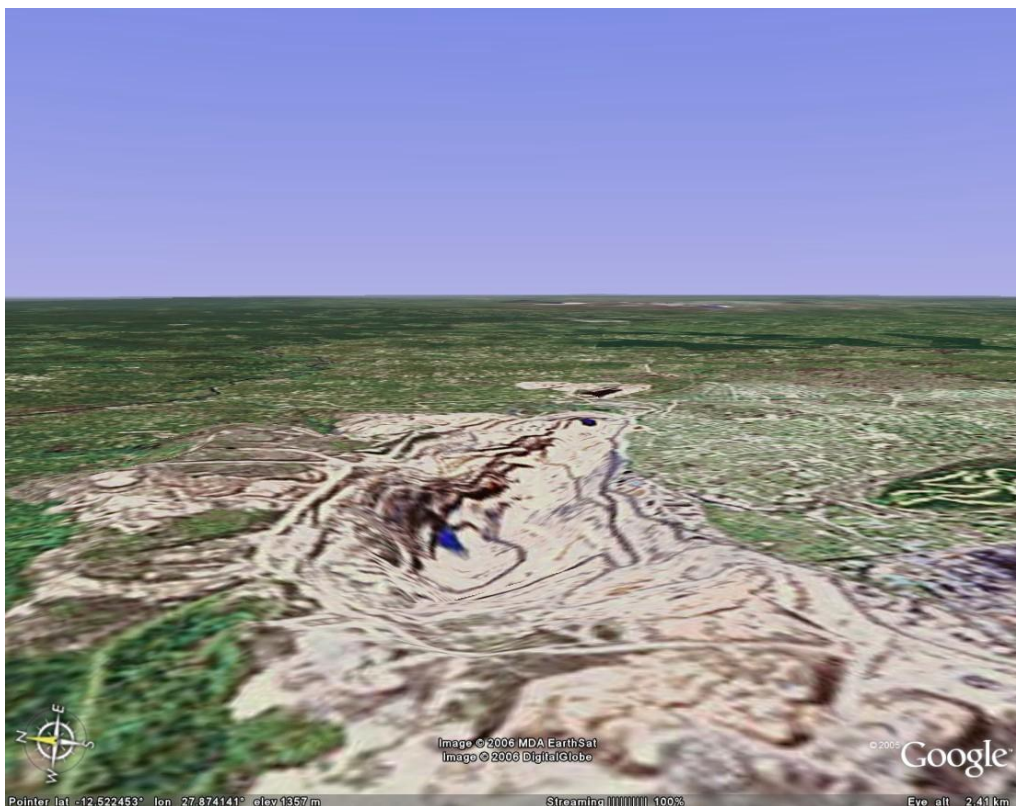
### High resolution vs Low resolution imagery



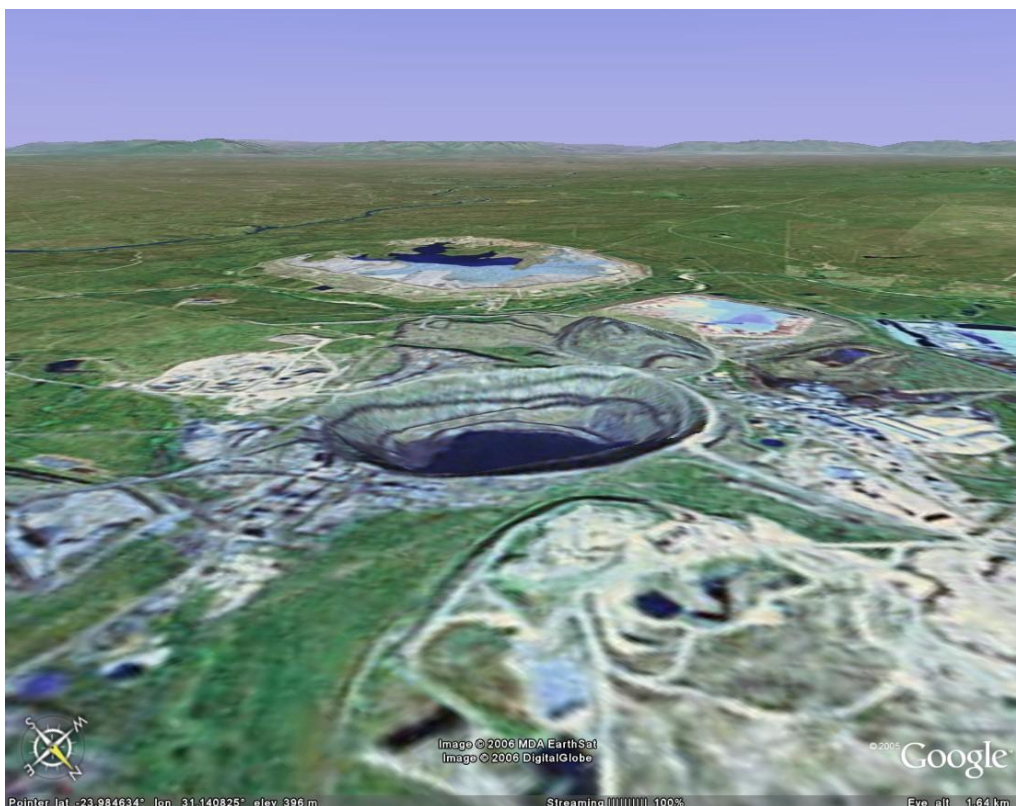
**Figure 9:** Image of Hernic Ferrochrome plant in Brits, South Africa, showing contrast between high and low resolution coverage [Image ©2006 DigitalGlobe]



## Terrain



**Figure 10:** Terrain in the vicinity of KCM Chingola open-pit copper mine in Zambia [Image ©2006 MDA EarthSat, ©2006 DigitalGlobe]



**Figure 11:** Terrain around Palabora Copper complex in Phalaborwa, South Africa, showing pit detail [Image ©2006 MDA EarthSat, ©2006 DigitalGlobe]

## CONCLUSIONS

Google Earth has shown itself to be a very capable application when used to explore the geography of metallurgical plants and their surroundings. The standard GIS features that the program provides are useful in their own right; however, when combined with the easily extendible KML format, it is able to not only display detailed imagery of the sites but also link any amount of useful information to the site simultaneously.

Google Earth will presumably continue to expand in both the resolution of the imagery of the planet available to it, and the functionality of the viewer application and the KML language. As its reach grows, so it will become an ever more indispensable tool for those in the mining and metallurgy field.

The creation of an open world data set of plant locations for Google Earth, with the possibility of extending the additional information stored to include general and statistical details of plant and process, has been proposed.

## ACKNOWLEDGEMENTS

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