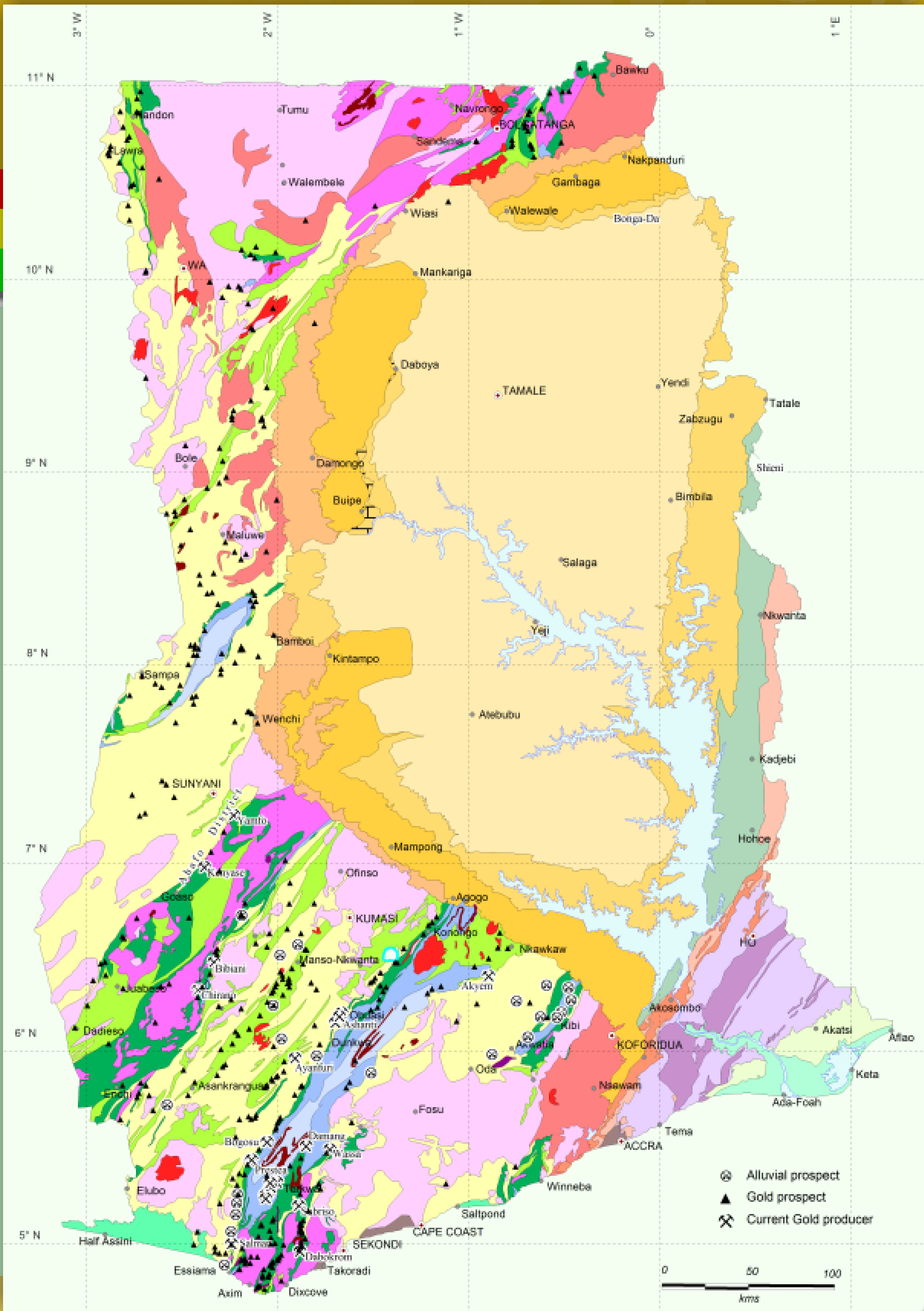
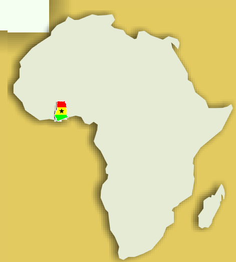
Gold Deposits of Ghana





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1 Historical Background

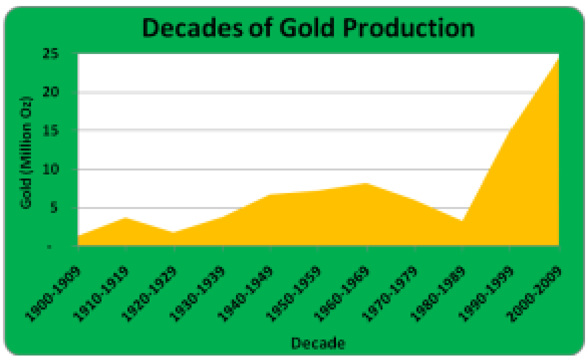
For centuries, gold and Ghana have been synonymous. Hundreds of years before the Portuguese sailors first arrived (late 1400s) along the coast of West Africa in search of gold, large quantities of this treasured metal had been mined and transported across the Sahara to North Africa. This trade helped to establish and support major trading centers in the Sahel along the course of the Niger River and contributed much to the main trading ports along the southern coast of the Mediterranean Sea.

The arrival of the European traders led to increased gold production within the forest areas of southern Ghana and the area became known as the Gold Coast. It soon became one of the most important gold-producing areas in the world and eclipsed other major producing areas in present day western Mali (Bambuk) and northern Guinea (Boure), which had been the earliest sources in West Africa that had fostered the development of several successive inland states/empires in the Sahel over a period of many centuries.

For a period of almost 400 years (1490s to late 1800s), European traders competed vigorously for gold brought to the many forts and trading posts strung out along the Gold Coast. Most unfortunately, the gold business was much diminished for almost 3 centuries by the diabolical slave trade and the coastal forts soon became way-stations for West Africans carted off to the New World where they were enslaved as plantation workers. This period was very disruptive to the gold trade, which recovered only in the early to mid 1800s, after slave trading was abolished in most countries and curtailed by the British navy who intercepted slave ships along the coast of West Africa.

In the late 1800s, when the emerging European powers were carving up their respective interests in Africa, Great Britain emerged the dominant European power along the Gold Coast and claimed it as a British colony in the mid 1870s. This marked the beginning of a new era in gold mining in the region as foreign companies were able to acquire gold concessions from local chiefs in very prospective areas in the interior of the country. By the beginning of the 20th century, modern gold operations began to emerge in many districts of southern Ghana.

During the colonial period, gold exploration and production waxed and waned according to economic conditions in the world economy. There was a huge but brief gold rush at the very beginning of the 20th century, which coincided with the Boer War in South Africa, and a much more sustained one throughout the 1930s when gold production reached historical highs and world-class operations developed at the famous Ashanti mine in Obuasi and in the Tarkwa, Prestea, and Bibiani districts



After World War II and leading up to Ghana's independence in 1957, the gold production remained substantial and the mines were critical to the economy of the new nation. However, the rising costs of production at a time of a fixed gold price made many of the existing operations marginally profitable, except for the Ashanti mine whose traditionally very high grades kept it amongst the premier gold producers in the world. In the early 1960s, the Government of Ghana bought out several of the marginal producers and formed the State Gold Mining Corporation. This parastatal company achieved very good results in the 1960s and early 1970s but a sustained lack of capital investment in the existing operations led to a downward spiral in production throughout the 1970s and early 1980s. Furthermore, there had been little if any new exploration since the 1930s, so no new producers were on the horizon.

It was not until the mid 1980s that the downward trend was reversed as a result of the implementation of a broad Economic Recovery Programme, which included a significant focus on the mining sector. This resulted in updated laws and regulations as well as fiscal incentives to attract foreign capital to carry out exploration and the development of new producers or the upgrading of existing gold operations. As will be seen in the statistics below, these new policies were extremely successful and created the necessary 'enabling environment' that culminated in huge capital expenditures on exploration and development projects.

Dramatic increases in production were achieved and have been sustained for the past 20 years during which Ghana has been the 2nd largest gold producer in Africa and over the past few years the country has broken into the top ten world producers. Ghana's success has become a case history for many developing nations, especially with respect to stimulating exploration and mining.

During the latest exploration boom, much of the early interest naturally focused on previous producers and the implications of new treatment schemes to more effectively mine lower grade deposits at mines that had closed down. In addition, many of the older mines now had more reason to re-evaluate known resources on their extensive concessions and to bring in new ideas and ways to increase production. This was especially true at Obuasi where a new and enlightened management team undertook huge development schemes that greatly increased gold production from about 250,000 ozs in the mid-1980s to almost 1 million ounces in the mid-1990s.

In addition, the Government's efforts to disassemble and privatize the exploration and mining assets of the State Gold Mining Corporation were finally successful in the early 1990s and subsequent developments have seen very impressive production increases. For example, in Tarkwa, the old underground operations were producing a very modest 20-40,000 ozs/yr in the late 1980s through the mid-1990s but Goldfields started a very large low-grade open-pit operation in the late 1990s and saw production shoot up to over 300,000 ozs by the end of the decade and for the past several years it has been the #1 producer in the country at over 600,000 ozs per year.
In addition, the Newmont group, who had inherited several prospects in the Ahafo area on the north side of the Sefwi Belt, discovered a world-class district that has very quickly become the #3 producer in the country keeps expanding production. Newmont is also now developing the very large Akyem deposit on the NE margin of the Ashanti Belt.

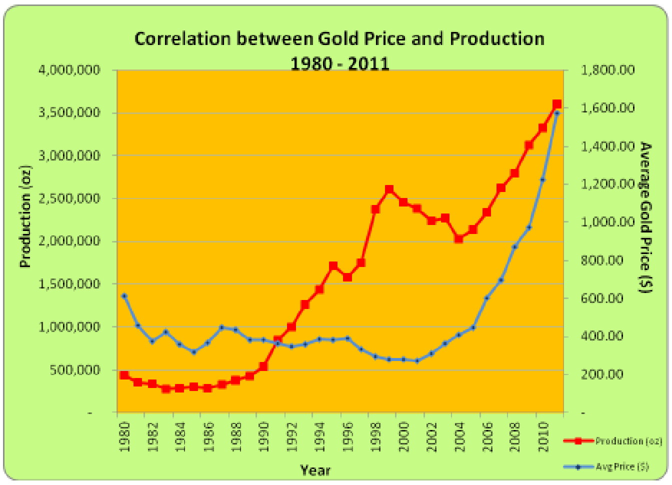
Ghana plans to maintain an 'enabling environment' for investment in the mining sector. This starts with a full commitment to good governance and the strengthening of democratic institutions that has gained the nation much favourable attention in recent times. It also includes modifying laws and regulations to improve the overseeing and administering of exploration and mining activities as well as establishing a fair and equitable distribution of the profits from mining in the country.

2 Production over the Ages

As can be observed in the accompanying illustrations, gold production in Ghana has been very significant over the ages and has kept Ghana as the pre-eminent producer in the region. It is especially noteworthy that over the past 20+ years, Ghana has seen a steady increase in production to the present historically high levels of over 3.6 million ounces per year. This has allowed the country to keep its #2 position in Africa and to break well into the top 10 world producers.

Gold production within the present day boundaries of modern Ghana, as well as into parts of neighbouring Cote d'Ivoire, probably started around 1000-1200 AD, due mainly to the influence of their northern neighbours in the Sahel who had been mining and trading gold from the goldfields in the Bambuk and Boure regions (Mali, Guinea and Senegal) for many generations.

The impact of European traders certainly must have stimulated local gold production, which is estimated to have been 40,000 ozs/yr during the 16th and 17th centuries, when the 'Gold Coast' was a major producer. Production was however affected by the trans-Atlantic slave trade, dropping significantly, probably to 25-30,000 ozs/yr by the beginning of the 18th century. By this time, European nations had decided to forcefully colonize virtually the entire continent.



The colonial period lasted about 80 years until 1957 when Ghana gained full independence and the impact on the gold mining business during this period was quite profound, with production in the colony (Gold Coast) exceeding 400,000 ozs/yr by World War I (1914). The period after the war witnessed great expansion of gold exploration and production in the Gold Coast, with annual gold production exceeding 800,000 ozs, coming from 15 operating mines, and catapulting the Gold Coast into the top 10 producers in the world. Heading towards independence in the mid 1950s, production averaged around 800,000 ozs/yr, despite interruptions from strikes and increasing costs.

From the early 1970s until the mid 1980s, gold production was on a downward spiral despite much improved prices. This was especially apparent in the early 1980s, when the gold price soared to over 400 USD/oz. The total gold production averaged less than 300,000 ozs/yr from 1982 through 1985. The situation was reversed quite dramatically in the mid and late 1980s when a new fiscal regime and more competitive mining regulations were introduced by the Government and the price of gold remained well above 300 USD/oz. Improvements were almost immediate and by the end of the decade, gold production was back up to about 500,000 ozs/yr.

Huge investments into the gold sector in the early 1990s produced large increases in production as can be seen in the accompanying graphs. By 1993, gold production in the country exceeded 1 million ounces for the first time. Production exceeded 2 million ounces in 1998 and by the dawn of the new millennium, annual production peaked at about 2.5 million ounces. The low price of gold early in this decade saw a significant drop in production to about 2 million ounces in 2004 but the drop was short-lived and since then, there have been steady increases. The 3 million ounce level, including a sharp increase in small-scale production (500,000+ ozs/yr), was toppled in 2009-2010. In 2011, Ghana produced 3.6 million ounces, and further increases can be expected if the gold price remains above 1500 USD/oz.

The Government of Ghana recognizes that in order to keep production levels high, exploration activities must be encouraged by favourable fiscal policies and maintaining that critical 'enabling environment', which will attract a significant share of worldwide exploration capital. Certainly the geological potential of the country remains very high as will be shown in the following sections.

3 Geology and Types of Gold Deposits

The geology of Ghana in very simplified terms is dominated by 3 main geological 'domains'. Half of the country is immediately underlain by Early Proterozoic (mostly around 2-2.2 billion years old) metamorphosed Birimian sediments, volcanics and intrusions. The other half is split by the large Volta Basin of mainly flat lying sediments (about 1-0.4 billion years old) in the central north of the country that mostly overlie the older Proterozoic units, and a long belt of highly tectonized and metamorphosed units (Pan-African; approx. 0.6 billion years old) along the mainly rugged eastern margin of the country.

The vast gold endowment of the country is essentially confined to the Early Proterozoic units and the modern rivers and valleys that drain these areas. The Early Proterozoic features broad basins of marine sediments along the margins of comparatively narrow, NE trending 'greenstone' belts, which contain a great variety of volcanics, sediments and intrusions. The broad basins include a variety of very thick, marine clastic sediments, which were later intruded by massive granitoid batholiths, probably formed by the melting of the metasediments at great depths (anatexis). The primary gold deposits are mainly confined to the 'greenstone' belts, especially along the margins of these belts and the adjacent basin sediments. The dominant types of gold deposits seen in Ghana are outlined below.

Birimian-Hosted Deposits

Although the early European explorers in the late 1890s were initially attracted to the Tarkwa district where gold mineralization similar to the vast deposits of the Witwatersrand was known, it was really the opening up of the high-grade quartz vein systems at Obuasi in the Ashanti Region that spurred on future generations of explorers. These vein systems produced some of the richest gold deposits in the world and they are being mined to this day. These deposits are now generally describes as **'orogenic gold deposits'** and they are amongst the most prolific producers in the world.

The **'Ashanti-type'** of gold occurrence usually features complicated quartz vein systems commonly associated with extensive disseminated sulphides. The vein systems usually appear to be related to regional NNE to NE trending regional structures (tectonic corridors), which are typically concentrated along the margins of various Birimian 'greenstone' belts and adjacent metasedimentary basins. The most favoured hostrocks are usually interbedded argillites, greywackes and volcaniclastic units frequently deposited in the transitional zones between the belts and basins. These transitional zones also commonly feature a variety of fine-grained chemical sediments (siliceous, graphitic, manganese, carbonate, fine-grained sulphides etc). It is also quite clear that in some areas, intermediate intrusions and mafic volcanics also host important gold occurrences.

These gold deposits feature extensive, steeply dipping, vein systems, usually with multiple stages of mineralization and veining. In some deposits, the veins are relatively narrow (1-2m) and discrete and there may be several parallel sets within broad structural zones. Not all vein systems are created equal; some are relatively barren in gold whereas others can be extremely high-grade. Individual vein systems can be traced for long distances along strike (1000+m) and be up to 10+m wide (Obuasi, Bibiani) although most are narrower (Prestea, Konongo). The veins also can extend to considerable depth (500+m). An individual vein system can pinch out rapidly but a separate one can be discovered along strike, down dip or anywhere within the confines of the broader, favourable structural zone.

The mineralized veins often feature medium to fairly dark grey quartz and commonly contain visible gold along with relatively abundant granular pyrite and arsenopyrite, usually in relatively fine-grained, acicular form. However, in many of the mineralized vein systems, visible gold is quite uncommon. In the more fortunate vein occurrences (Obuasi, Prestea), much of the gold (40-60%) occurs in a free-milling form whereas the remainder is usually tied up within grains and crystals of pyrite and/or arsenopyrite. Gangue minerals typically include chlorite, sericite, carbonate and carbonaceous matter, which give the veins the grey colour seen in many of the major and minor deposits.

The quartz vein systems are intimately tied up with wide zones of disseminated sulphides in the hostrocks. This feature has long been recognized at virtually all of the major gold producers but the zones were too low grade to be mined in the past. However, in recent years, they have become very important sources of new ore reserves. The disseminated sulphides consist mainly of pyrite and arsenopyrite in variable amounts. The gold in these zones is frequently locked up in the sulphide minerals on a submicroscopic scale and a lot of the mineralization is highly refractory. However, some of the more recent major gold discoveries (Ahafo, Akyem, Chirano), which include vein systems and disseminated sulphides, appear to contain mostly free-milling gold within the sulphide zones.

There appears to be a relatively common alteration pattern at most of these occurrences that features varying amounts of silica, carbonate, sericite, chlorite, and alkali feldspar. Albitization has become increasingly recognized in recent years in many deposits and carbonate replacement of the original hostrocks is quite pervasive in some deposits, especially in the new Ahafo district of the Sefwi Belt. Some of the vein systems have relatively narrow alteration envelopes whereas others are much more extensive. In fact, the broad disseminated sulphide zones are generally highly silicified and form part of the alteration envelopes of the mineralized systems. Many of these systems produce lozenge shaped deposits, which feature a higher grade core and lower grade margins.

It has long been recognized that on a local scale, structure is probably the key factor in controlling lode gold deposits in southern Ghana. Most of the early workers recognized the favourable structural settings, particularly along the northwestern margin of the Ashanti Belt where most of the major lode deposits are located. The same can be said for the major new discoveries in the Ahafo district along the northern margin of the Sefw Belti. The substantial occurrences at Chirano occur along a highly tectonized section on the southern margin of the Sefwi Belt. Interestingly, the important new discoveries at Akyem occur along a major shear zone on the southern margin of the Ashanti Belt.

The term 'structural corridor' for many of the structural zones along the margins of the belts and basins is appropriate because they certainly feature a variety of structures of considerable complexity. Many of these zones were originally developed during the protracted Eburnean orogenic cycle, which peaked around 2100 million years. Intense strain was concentrated along these zones because of the marked contrast in the competency of the basin sediments and the volcanic belts. Most of these 'structural corridors' appear to display both ductile and brittle strain features and thus demonstrate that the mineralizing events occurred from very deep (15+km) to quite shallow (-5 km) crustal levels. These extensive structural zones provided an excellent plumbing system for vast quantities of mineralizing fluids, provided by the basin sediments and from metamorphism of deeply buried sediments and volcanics within the greenstone belt.

Deposits Hosted in Birimian-age Intrusions

For many decades, granitoids were not considered to be especially favourable hostrocks for gold mineralization in southern Ghana. However, in the recent exploration boom, as more systematic exploration was carried out in areas with known gold vein occurrences, a few important occurrences were discovered where granitoids have turned out to be very favourable hostrocks. Almost invariably, these granitoids are intermediate in composition and they are close in age to the Birimian hostrocks and are pre-metamorphic (pre-Eburnean).

In fact, this is just another variety of orogenic gold deposits, very similar to those described above but hosted in granitoids. The alteration (strong silica and carbonate introduction) and sulphide mineralization (dominantly pyrite) are very similar to many Ashanti-type deposits although with little arsenopyrite and mainly free-milling gold that is rarely visible to the naked eye.

Some of the best examples of this type occur on the north side of the Sefwi Belt in the rapidly emerging, world-class Ahafo gold district, which is now being developed on a very major scale by Newmont. Here, there are several major gold deposits hosted in intermediate intrusives that are pre-orogenic and close in age to the surrounding Birimian units. On the south side of the same belt, there are a series of significant gold deposits in the Chirano area that are also hosted in intermediate granitoids. Pyrite is very common and often closely reflects the amount of gold present. The mineralized systems in these major new discoveries also occur over a very broad range from high level brittle fracture to much deeper ductile structural conditions.

In the early 1990s, exploration at Ayanfuri outlined several gold deposits hosted in intermediate granitoids; the mineralization is contained mainly in quartz stockwork systems. Shortly after the Ayanfuri discoveries, work in the Manso Nkwanta district also revealed a very similar pattern where comparatively small intermediate granitoids and the metasedimentary hostrocks contain numerous significant gold deposits. In very recent years, a lot more gold mineralization in granitoids has been discovered in these areas.

In southern Ghana, there are few if any significant gold deposits associated with late-stage, intermediate to felsic intrusions of the type that occur mostly in the broad sedimentary basins and which formed late in the Eburnean orogenic cycle. This is probably due to the fact that they are far removed from most of the tectonic/structural activity and also from most of the primary sources of gold. Nevertheless, they may actually play significant roles in the grand scheme of things by acting as 'heat engines' driving fluids from the basins into the structural conduits along the margins of the basin and adjacent belt(s).

Tarkwaian Paleoplacer Deposits

The conglomerates of the Tarkwa district have now produced about 12 million ozs of gold over the past 100 years and although the last remaining underground mine closed in 1999, the district now has very substantial open-pit gold production and the regional resource potential is excellent. To date, virtually all of the gold mined from Tarkwaian paleoplacers, also known as banket deposits, have come from the immediate vicinity of the Tarkwa district. Similar Early Proterozoic sedimentary sequences are known in many of the other belts in Ghana and neighbouring belts of West Africa, where there are some minor gold occurrences. However, as yet, none of these have been developed into major mines.

In the Tarkwa district, the 'basal' or B conglomerate in the Banket series usually contains the best gold values but the overlying conglomerates also contain substantial gold and the intervening cross-bedded quartzites frequently contain low values. On the eastern margin of the Tarkwa Syncline, where most of the underground mining has been concentrated, the banket conglomerates are comparatively thin (often less than 1m), whereas they thicken to the west.

The high-grade zones (15-45g/t) are largely confined to the thin conglomerate beds that contain a high proportion of well-rounded, coarse quartz pebbles, cobbles and boulders. The gold is virtually restricted to the matrix of the conglomerates where it occurs as quite fine (10-15 microns) grains or clusters, often in zones with abundant hematite. Tarkwaian gold is typically very pure, with a fineness commonly exceeding 950.
The entire conglomeratic sequence appears to be about 30-45m thick on the eastern margin of the Tarkwa basin but thickens towards the west to about 60-75m and to about 100m towards the north. Individual lenses of banket conglomerate vary in length from 600-1000m and in width from 100-150m. The general current directions consistently indicate a source area for the conglomerates and sandstones to be from the east, southeast and south.

The sedimentary features of the banket series indicate that the sediments may have developed as a series of alluvial fans on a piedmont surface. Braided streams originating largely in the east during a fairly wet climatic period dispersed the sedimentary debris. The braided channels joined up in the central part of the basin and then flowed to the north. The basin itself appears to be a half-graben structure bounded on the west by steep faults. Modern analogues may perhaps be seen in the East Africa Rift Valley or along the Salton Sea in southern California.

Although a few geologists have speculated on an epigenetic origin for the Tarkwaian gold occurrences, the vast majority of opinion by those most familiar with the area, are essentially unanimous that these deposits are true paleoplacers. They bear striking resemblances to the huge paleoplacers of the Witswatersrand Basin of South Africa.

Tarkwaian-Hosted Vein Deposits

Quartz veins are very common in the Tarkwaian Group but, historically, these have been of no commercial interest. This all changed in the late 1980s when a large mineralized stockwork system was discovered and developed at Damang, just to the NNE of Tarkwa.

The Damang quartz stockwork system is hosted in the Banket Formation units on the east limb of a tight anticlinal structure with a NNE trend. The fracture system has been traced for several kilometres along strike and features two dominant, generally NS trending vein systems; one dips shallow (20-35°) to the east whereas the second set dips more steeply (60-75°) to the east.

The fracture systems also appear to be related to a late-stage regional fault. Although the quartz veins contain some visible gold, the majority of the gold is located in the selvages of the veins in close association with extensive silicification, pyrite and pyrrhotite mineralization. The veins contain negligible sulphides and show minor but persistent indications of carbonate, sericite, tourmaline and ilmenite. Virtually all of the gold is non-refractory.

In reality, these occurrences are just another type or style of orogenic gold deposit that probably formed fairly late in the Eburnean tectonic cycle and the gold could have originated either from nearby Tarkwaian conglomerates or from existing Birimian occurrences.

Oxide and Laterite Occurrences

Virtually all of the primary (and paleoplacer) gold deposits in Ghana and neighbouring areas have been deeply weathered to produce oxide caps. These oxide cappings (also called saprolite) have been a major target for exploration over the past two decades because they are usually amenable to inexpensive surface mining and treatment schemes.

Oxide deposits are gradational with underlying primary mineralization and the extent of oxidation is usually dependent on the climatic conditions and landforms. Oxide caps on the crest or flanks of hills may be 50-100m thick whereas oxidized zones in low-lying valleys may be less than 5m thick. The lateral extent of oxide zones, in most cases, is largely controlled by the geometry and nature of the underlying primary mineralization and by the extent of the in-situ weathering. Typically, most of the oxide zones of gold deposits in southern Ghana do not develop pronounced mushroom-shaped vertical profiles and most of the oxide zones are only marginally larger than the underlying primary zones of mineralization.

It also generally appears that the overall grades within the oxide zones are similar to underlying primary mineralization and that supergene enrichment within the oxide zone does not appear to have been very extensive although there may be important exceptions to this general trend. Within the oxide zones, the gold appears to be relatively evenly distributed in a very fine-grained form, which is easily recovered in conventional milling systems or by heap leaching.

The effects of oxidation have had a particularly beneficial effect on deposits with extensive disseminated sulphides in the primary zone and where a high proportion of the gold was originally contained within sulphide grains. The liberation of gold from the sulphides has rendered many of the oxide caps suitable for mining whereas the underlying primary zones may be too low grade to justify more expensive refractory recovery systems. The physical effects resulting from the weathering have also resulted in many benefits such as softer ores that require minimum blasting as well as substantially increasing the permeability of the hostrocks, which may permit very low-cost heap-leach methods to recover the gold.

These beneficial effects are not just confined to the mineralized vein systems and accompanying disseminated sulphides in Birimian units and belts intrusives. They have also had substantial benefits in the near-surface exposures of the Tarkwaian paleoplacers because the hostrocks are softer and have a higher permeability, which permits very effective heap leaching of relatively low-grade mineralization.

Late Quaternary Deposits

The vast majority of historical gold production from Ghana prior to the 20th century came from a myriad of small streams and rivers draining areas with underlying oxide and primary gold deposits. In addition, several of the major rivers have been mined with dredges starting in the early 1900s, and in the 1990s, large alluvial operations were started up on rivers in numerous districts. With the steady increase in the gold price over the past several years, the amount of small-scale gold mining, primarily of alluvial deposits, has increased dramatically throughout Ghana.

There is very little detailed information on the ages of the alluvial terraces and river sediments observed in the present inland river system but most appear to be relatively young and are probably of Late Quaternary age. During the last major Ice-Age, the sea level may have been up to about 100m below the current level and at the end of that Ice-Age, perhaps around 10,000 BP, much of southern Ghana had a savannah climate characterized by low rainfall and fairly sparse vegetation. This was followed by a very rapid increase in rainfall that resulted in enormous erosion and down-cutting of most of the main river valleys throughout southern Ghana. A great deal of gold was eroded from all the near-surface deposits in the region and added to the alluvial gold in the existing rivers.

While there remains a substantial amount of alluvial gold in the river systems of southern Ghana, there is also little doubt that a very considerable amount of gold was discharged along the coastal region where the major rivers enter the Gulf of Guinea. Since the sea-level at that time was considerably lower than today, it would seem reasonable to conclude that a very substantial amount of gold was deposited in the current offshore region.

4 Genesis of the Gold Deposits and Exploration Potential

The exploration potential of the Early Proterozoic units of southern Ghana is well-proven by the dramatic increases in production since the mid-1980s when significant exploration finally got underway after almost 5 decades of inactivity. Since then, many new ideas have emerged about the regional geology and the nature of the gold mineralization in many parts of the country.

It is now fully recognized that southwestern Ghana, especially the Ashanti and Sefwi belts, has been endowed with impressive concentrations of gold in what is a relatively small area. The sizes and quality of the deposits are clearly world-class. The geological reasons for this are now becoming clearer, and although our knowledge of the details of these deposits is hardly complete, there seems to be a general consensus as to the geological conditions that have favoured this particular region.

The essential ingredients for major gold districts are the presence of a large primary source of gold, vast reservoirs of fluids, structural conditions whereby the fluids can be focused along permeable channels and find conditions where the gold can be deposited in significant concentrations. In the case of Ghana, as well as other parts of West Africa, the Early Proterozoic provided almost ideal conditions in many areas.

First, the area featured extensive magmatic activity that resulted in the development of many new volcanic chains or belts with extensive sedimentary basins adjacent to the volcanics. The volcanic units may have been enriched with low levels of gold and certainly some of the volcanic/hydrothermal emanations along margins of the belts and basins produced chemical sediments that were enriched in gold, silica, sulphides, manganese, carbonates, and often carbonaceous matter, which was probably organic in origin. Almost certainly, there were also significant early vein systems that carried abundant gold, which was likely the source for much of the Tarkwaian paleoplacers.

The connate waters from the basins, along with waters resulting from metamorphism at deep levels in the basins and belts, provide an abundance of fluids, which were mobilized during the protracted Eburnean Orogeny, a major tectonic event that peaked at about 2.1 billion years. This resulted in the closure of the Early Proterozoic marine basins and the plastering of now highly folded and faulted Birimian terrane onto the margins of an older cratonic block to the east of present day Ghana. While all this was going on, gold was being deposited in many different structural environments at all levels in the upper crust and earlier deposits were probably being remobilized and, in many cases, enriched.

Major regional structures have played a seminal role in the distribution of gold. Most of these were concentrated along the margins of the volcanic belts due to pronounced competency contrasts with the adjacent sediments; this is where the fluids would be channeled and it is where primary concentrations of gold were probably available to the fluids being flushed through the hostrocks. Along these favourable structural corridors, mineralization took place from quite deep levels (15+ km) where high temperatures and pressures favoured ductile strain all the way to much shallower levels (less than 5 km) where lower temperatures and pressures resulted in brittle fracturing along the structural corridors.

By about 2 billion years ago, the Eburnean Orogeny had waned, except for perhaps a few late gasps of alkaline magmatic activity, and a very large regional mass of intensely deformed Early Proterozoic units had been accreted onto older Archean blocks and become new continental crust of great thickness. The area had been considerably uplifted but, by about 1.5 billion years, it had been eroded down to a fairly flat surface. No doubt the erosion exposed and removed considerable gold mineralization across the West African region, which was subsequently covered by mostly thick, Late Proterozoic (Voltaian Supergroup) sequences of shallow marine and continental sediments, including some glacial deposits.

The Birimian units, with much of their vast gold endowment still intact, were well preserved, thanks largely to the widespread Voltaian sediments, until about the Tertiary Period (approx. 30-60 Ma) when regional uplift led to extensive weathering and erosion. Slowly the protective Voltaian cover was peeled away and the underlying Birimiam exhumed. It is likely that since the Early Tertiary, in many areas of southern Ghana, 100 - 500m of material has been eroded away, including large amounts of gold exposed along the margins and in the interior of the Birimian greenstone belts. Much of this was probably transported into the offshore environment.

From the above, it is pretty clear that there are many areas throughout southern Ghana where the gold potential remains very high. The very extensive nature of the mineralizing systems suggests that many new discoveries of more deeply buried deposits will be made in virtually all of the existing districts. This has been the history of many of the older operations, which discovered new orebodies at depth and this will almost certainly continue as more systematic, deeper drilling is carried out.

The margins of the belts and basins remain very prospective and those sections of the margins, which have been most highly tectonized, are likely to be especially favourable. It is these zones that often provide the most effective plumbing systems for fluids driven in from the basin and up from underlying sediments and volcanic undergoing various stages of metamorphism.

While the Ashanti Belt has been the dominant producer in Ghana/West Africa for the past 100+ years, in the past 2 decades, the Sefwi Belt has assumed increasing importance. Twenty years ago, there was very little evidence whatsoever to suggest that the Ahafo district on the north side of the belt would become a world-class district with potential for much more than the present 20+ million ounces of defined resources. At the same time, the major Bibiani deposit on the south side of the belt appeared to be pretty well isolated but by the late 1990s, the Chirano area demonstrated that the district extended much further to the south where large gold resources are now being mined. This belt remains highly prospective.

On the Ashanti Belt, the Akyem deposit occurs in an area with few apparent indications of major Birimian hosted gold deposits and which had been quite overlooked, or at least underestimated, until the mid 1990s when regional work revealed a major soil anomaly that eventually led to a multi-million ounce gold resource in Birimian units. This southern margin of the belt remains relatively under-explored.

The neighbouring Kibi-Winneba Belt contains extensive alluvial deposits that are especially well-developed and of economic significance along the flanks of the prominent Atewa Range, which has a maximum relief of up to 500m. There are a few known bedrock sources for the alluvial gold and some recent exploration activity in the immediate vicinity has been very encouraging but overall, the belt has been very much under explored.

In the central-west and northern parts of Ghana, the Early Proterozoic terrane has also not attracted very systematic exploration until quite recently. Some of the greenstone belts in these areas appear to feature fairly high-grade metamorphism and that the levels of erosion are deeper in these areas than in the southwest of the country. Nevertheless, it is clear that gold mineralization in orogenic systems extends to quite deep crustal levels and that many of these northern belts host substantial gold mineralization. To date, the amount of exploration in most of the northern belts has been quite limited. Nevertheless, some significant discoveries have been reported and sustained work will no doubt identify more deposits of economic significance.

Recent geophysical data has confirmed, as expected, that the mainly Late Proterozoic Volta Basin in central and northern Ghana directly overlies Early Proterozoic greenstone belts and basins. There is little doubt that the Kibi, Ashanti, Sefwi and Bui belts extend for several hundred kilometers under the basin and the buried portions of the belts probably have similar economic potential as the exposed areas. Of course, the central part of the Volta Basin is prohibitively deep for any gold exploration in the foreseeable future. However, some areas on the margins, particularly along the immediate extensions of the Ashanti and Sefwi belts are only a very few hundred meters deep and could be very prospective. The same can be said of extensions of the Bui and the Bole-Nangodi belts that are overlain by quite thin Voltaian units. It is also quite possible that coarse clastics at the base of the Volta Basin could contain significant plaeoplacer gold eroded during the Middle Proterozoic.

Alluvial gold has been the mainstay of small-scale mining for countless generations in SW Ghana and this region continues to have quite considerable potential, which is demonstrated by the intense activity in the past few years as gold prices have remained very high. Although a great deal of the alluvial gold has already been extracted from the inland river systems, there still remains a very significant resource.

Schematic Cross-Section of Birimian Terrane with Various Types of Gold deposits