King Fahd University of Petroleum & Minerals

The Distribution of The Gold Mineralizations In Relation To The Structural Geology, Southern Arabian Shield

A PROJECT REPORT

CRP 514

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I. INTRODUCTON

Most of the gold ores in the southern region of the Arabian shield are deposited as viens within fissures and fractures associated with the major geologic structures resulted from various tectonic cycles.

ArcView, desktop software, will be used objectively to solve the formulated problem in the execution process of this project. The software has been proposed to achieve this goal due its good capabilities in loading, analyzing and displaying the special and tabular data. It provides several tools needed to query and analyze data, and present it as presentation quality maps. Time effectiveness is the most important advantage the software has.

II. PROBLEM STATEMENT

Most of the gold mineralizations in Saudi Arabia are located within the Southern region of the Arabian Shield. The investigated gold deposits are deposited as viens within fissures and fractures associated with the major geologic structures resulted from various tectonic cycles.

The study aims to support this well-known hypothesis and to provide a meaningful spatial relationship between gold occurrence and orientation, the major fault (see figure 2a)systems and volcanic and plutonic intrusions (see figure 2b)within the region.

III. OBJECTIVE

The project aims to demonstrate a practical use of the ArcView software to solving a real–life problem. The main purpose of the study is to provide a meaningful spatial relationship between gold occurrence and orientation, the major fault systems and volcanic and plutonic intrusions within the region.

IV. LITERATURE REVIEW

Database mapping started early in the 1950s and 1960s when it was inidated by scholars for research purposes. The name 'Geographic Information Systems" appeared for the first time in the 1iterature in the mid of the nineteenth century when the first cartographic base maps were generated and helped pave the way for thematic mapping. Advances achieved in many branches of science, especially mathematics and computer, largely contributed in later developments in the field of GIS technology. Automated thematic mapping started in United States and Britain, whereas the first major Geographic information System was developed by the Canadian government by the late 1960s. Latest developments in the field of the technology are mainly attributed to the research work carried out in many universities, such as University of Washington, Harvard, and IMT, which have the main contribution to the major developments in the field. Popularity of the technology is basically referring to the enormous development achieved by giant commercial GlS packages such as ESRI, pMap, and IDRISI.

Geographic Information System can be generally defined as a computer based system, which is used to hold and analyze data about places on the earth surface (Rhind, 1989). The term itself is still debatable (Timmermans, 1994). The subject is defined as an organized assemblage of hardware or software used to capture, store, retrieve, and analyze different forms of spatial data (Burrough, 1986). It also has been defined and described in many ways as an integrated computer system for the input, storage, analysis, and output of spatially referenced data (Childhood, 1988).

Basically, there are two types of GIS data spatial or geographic data indicating the geographic location of a certain feature and the attribute data which contains the descriptive characteristics of the geographic feature (Aranoff, 1989). There are two basic types of formats, the vector and raster based format (Aranoff, 1989). Raster based format stores data structure as arrays of grid cells with a separate layer for each attribute. It's commonly used for the classification, analysis and use of satellite images (Wiggins and French, 1991). The vector based format attempts to represent the position of a geographical feature as precise as possible by one or more paths of coordinates. It uses topological data structure and the basic elements of the map ate represented by points, lines or polygons (Wiggins and French, 1991). Topology describes the relationships between the elements of a map.

GIS technology is unique and differs from other computer packages that can equally handle spatial data because GIS has the capabilities of performing spatial operation or integrated analysis on geographically referenced data (Aranoff, 1989). GIS combines the analytical capability of database management with high-resolution computer graphics (Rhind, 1989) base on proximity and the combination of attributes from multiple sources and by crea60n of new data. Thus GIS significance results from its ability to relate attribute data to geographically referenced data within the system.

GIS enhances improved productivity in providing public information; improved efficiency in updating and storage of data; ability to track and monitor growth and development over time and in the rapid performance and display of different professional analysis. Also GIS enhances better decision-making and the ability to integrate data for specific sub-areas (Aranoff, 1989 and Wiggins and French 1991). However, GIS implementation is constrained by many problems such as lack of well-trained staff; management support;

difficulties with data input and conversion; maintenance of databases, map generalization and visualizatio issues.

V. STUDY AREA (SOUTHERN PART OF THE ARABIAN SHIELD)

1:1,000,000 scale map, for selected mineral occurrences of the Arabian Shield showing their relationship to major tctonostratigraphic entities prepared by the Ministry of Petroleum & Mineral Resources (Jiddah), will be digitized to display the distribution of the gold ores and major faults and fractures in the study area.

VI. GEOLOGIC SETTING OF THE SOUTHERN ARABIAN SHIELD

Stratigraphy:

The Precambrian rocks of the southern part of the shield were divided into eight major stratigraphic units, of which seven were given group status. The oldest were considered to be the Khamis Mushayt Gneiss and Hali Groups of which the former could be a basement complex older than the later.

The Khamis Mushait Gneiss and Hali Groups are more probably, at least partly, highly metamorphosed equivalents (amphibolites) of some of the layered rocks described below and of plutonic rocks intruded into them. Metamorphism in Hali group is ordinarily that of the greenschist facies and most of the rocks have been intensely deformed. The greenstone Baish Group overlies the Hali Group. A thick sequence of metasedimentary rocks above the Baish Group has been assigned to the Bahah Group and consists mainly of quart-chlorite-sericite schist.

The Jeddah Group has been placed above the Bahah Group because its style of deformation, degree of metamorphism, and andesitic composition relate it more to the succeeding groups than to the Baish and Bahah Groups.

The Ablah Group, consisting essentially of andesitic and dacitic volcanic rocks with some slate and marble, is regarded as separate units between Jeddah Group and the succeeding Halaban Groups. The Halaban Group has been divided into a predominantly clastic lower part with Conglomerate and Sandstones, a predominantly andesitic Middle part, and an upper part of silicic flows and pyroclastic rocks. Most of the Halaban Group has been metamorphosed to greenschist facies. The succeeding Murdama Group of predominantly metasedimentary rock is characterized by a thick marble, massive conglomerates, sandstones, siltstone, and subordinate shale.

These Precambrian rocks of the southern part of the shield are overlain in places by the Precambrian to Paleozoic Shammar and Jubaylah Groups, respectively consisting mainly of rhyloite and of conglomerate, andesite, basalt, and limestone, and the Cambro-Ordivician Wajid and Siq Sandstones that now occur mainly around the eastern margins of the Shield.

Tectonism:

The occurrence of four major Precambrian tectonic episodes to be indicated by observed and presumed angular unconformities in the southern part of the Shield. The Khamis Mushayt Gneiss was thought possibly to have been involved in an earlier tectonic episode. The Asir tectonism was stated to be the oldest tectonic episode for which the evidence was clear, and the inferred basement tectonics of the Khamis Mushayt Gneiss were not separated from it. It was presumed to have caused the intense deformation and metamorphism of the Gneiss and the Hali Groups, in contrast to the greenschist facies of metamorphism in the Baish and younger groups.

The Baish and Bahah Groups and all the rocks were considered to have been deformed and metamorphosed during the Tihama orogeny. The extrusion of voluminous and widespread basaltic lava of the Baish Group was thought to signify an abrupt change in the evolution of the Shield and possibly the beginning of the Tihama orogeny. The change form the basaltic volcanism of the Baish times to the andesitic volcanism and dioritic plutonism of Jeddah- Halaban times were considered to signify another major change in crustal processes at the beginning of the Hijaz orogeny. This was defined as a series of tectonic events characterized by north-south wrench faulting and compressional folding; plutonism and volcanism were closely related to this deformation. The Murdama Group was folded about north-south axis and slightly metamorphosed during the Baishah orogeny in the south.

The Najd fault system, which enters the northeast of the southern part of the Shield, consists of prominent northeast-trending shear zones with left lateral movement and resulted from later accretion of an island arc.

Major Intrusions:

Large bodies of tonalitic orthogenesis have elongation and foliation conformable with schistocity of the enclosing Hali Group in some places; some of these bodies were considered to be possibly tonalite intruded during the Asir tectonism. Abundant metadiorite is probably the oldest plutonic rock associated with Hijaz orogeny in places it is cut by later hornblende diorite and even later quartz diorite. Large and small plutons of gabbroic to dioritic rocks cut the Jeddah Group and probably also the lower Halaban. Granodiorite, quartz monzonite, granite, and syenite are less abundant than the diorites and may have been contemporaneous with the upper Halaban rhyolites. Small gabbroic plutons and layered gabbro lopoliths intrusive into the dioritic rocks or localized along north-trending synforms of metamorphosed volcanosedimentary rocks may have been emplaced during Hijaz and Baishah orogenies or were perhaps genetically related to the north –south faulting.

Serpentine, largely antigorite and probably derived from peridotite, was emplaced along many of the north-south wrench faults that affected the Halaban and older rocks. Large bodies of plastically folded Khamis Mushayt Gneiss have risen as structural domes and antiforms into juxtaposition with younger rocks in some places; this probably occur mostly during or somewhat later than the culmination of the north-south faulting. Upper Precambrian or Cambrian granite plutons were intruded along the northwest-trending Najd fault system at about the time of cessation of fault movement.

<u>Genetic environment:</u>

The petrography of the igneous rocks of the Shield, and their evolution in composition from tholeiitic to calcalkaline, are similar to those of island arcs elsewhere. Collusion of a postulated neocratonic arc and the continent of Gondwanaland may have terminated the Hijaz tectonic cycle and initiated faulting, volcanism, and plutonism in the Najd fault system.

<u>Geology of gold Mineralization:</u>

The gold generally occurs in quartz fissure veins containing at least three generation of quartz, of which the second generally carries most of the gold. The gold Mineralization consists of hydrothermal quartz veins filling fissures in altered rocks. The veins tend to dip steeply and occupy faults, usually tensional and diagonal shear zones formed as secondary openings in connection with large wrench or strike-slip faults. Post-mineral faults are often parallel to district elongation, that is transverse to or at obtuse angles to the veins. Displacements on such faults are normal.

In the Arabian shields, the gold-silver ratio ranges from all silver to about twice as much gold as silver. The Mineralization may be classified into two general but overlapping types:

Gold-bearing quartz veins and

Gold-bearing sulfide veins.

Gold quartz Mineralization at ancient mines is indicated by an abundance of quartz waste dumps and by the absence of large smelter slag dumps, smelting being little used because the ores are free milling. The quartz is of two or more generations. The earliest generation consists of white granular quartz containing spare pyrite but little if any gold. After fissures reopened a second generation was emplaced consisting of grey gold-bearing quartz with accessory lead. zinc, and copper sulphides, hydromuscvite, and chlorite. A third generation of large barren quartz veins may have formed after further fissure reopening.

The gold-bearing sulphide veins are similar to the gold-quartz veins except that the gold occurs to a large extent in intimate association with pyrite and other metallic sulphide, which are present in large quantities in the veins. The ore from these veins is usually not free milling; therefore, large amounts of ancient smelter slags are present at or near the mines. In modern practice such gold can be recovered by gravitational concentration or flotation of the sulphides and cyanidation of the concentrates. Some mines in this class contain polymetallic ores of gold, silver, copper, and lead.

The gold deposits in southern Saudi Arabia are grouped according to the host rocks related to gold Mineralization. A genetic relationship between the gold-quartz veins and the felsic rocks in the Tathlith has been postulated. The veins can be traced from the auriferous quartz porphyry and pegmatite dikes to the granite and peralkaline granite stocks within hundred meters.

Most of the gold deposits in southern Saudi Arabia occur in the north-trending Tathlith belt. However, the gold veins in the Tathlith belt are mainly northeast trending, varying in direction from NNE to ENE, with a few trending NW at Umm Shat Gharb, Umm Shat Sharq, Hlmiya South, and Lugatah. Because the age of gold Mineralization in the Tathlith belt is approximately the same with the Najd faulting, the geologists believe that the gold Mineralization in the belt are related to the Najd orogeny.

The NE-trending veins can be interpreted as Mineralization along small faults parallel to the major faults, whereas the predominant NE-trending veins might be formed by the Mineralization following the normal faults or tension cracks related to the northwesterly strike slip movement of the Najd fault system.

VII. SPATIAL RELATION BETWEEN GOLD MINERALIZATION, FAULTS AND MAGMATIC INTRUSIONS:

The latest map showing the types and distribution of gold mineralization was constructed in 1994 by Peter Collenette and David Grainger (DGMR). The map portrays the physical distribution of the primary gold mineralizations based on their genetic origin. They stated that most of these mineralizations are clearly associated with the igneous intrusion and fault zones.

What so called GIS spatial analysis were performed objectively to reveal the influence of the adjacency to major faults and intrusions on the concentration of the primary mineralizations and to confirm the underlying geologic fact subsequently.

Gold deposits located only one mile or less from the nearest fault were precisely selected using the select by theme option of the theme menu. All gold deposits showing such adjacency to major faults, have high gold potentiality. According to the available literature (see fig.3). The selection result also showed a good conformity with the result displayed in the latest geologic map (see fig.1&4).

Using the same search criteria, gold deposits adjacent to major intrusions were selected, utilizing the select by theme option. All of these deposits are high-potential gold mineralization (see fig.3). The fairly correspond to the primary mineralization associated with the igneous intrusions as described in the previous map (see fig. 1 & 5).

According to the various spatial analysis carried out, the number of gold deposits associated with igneous intrusions is much greater than the number of those associated with major faults. This, most probably, is attributed to the association of the gold-bearing magmatic solutions with the intruded igneous stocks, which likely triggered minor faulting and fracturing responsible for the accommodation of the gold-bearing solutions.

Another obviously observed relationship is the juxtaposition between gold deposits associated with faults and intrusions. The analysis proved that most of these deposits are located within the vicinity of the major intrusion, which represents the source of the rich-gold magmatic solutions (see fig.6). Nevertheless, faults are crucial to the passage and accommodation of these solutions. This analysis was performed objectively in two steps using the select by theme option.

Tabular data containing the tonnage of major mines in the area have been analyzed to determine the maximum and minimum value of tonnage, using the statistics option of the Field menu. The mines with maximum and minimum tonnage were selected by the Select tool. It's found that the highest-tonnage mine is located very close to an igneous intrusion (see figure 7). Whereas, the minimum-tonnage mine is still obviously far from the nearest intrusions and faults (see figure 8). This indicates that the distribution of the gold mineralizations is entirely controlled by the magmetic intrusions and associated faults and therefore strongly support the premise previously mentioned.

VIII. CONCLUSION AND RECOMMENDTIONS:

The gold Mineralizations of the Southern Arabian Shield generally consist of hydrothermal quartz veins filling fissures in altered rocks. The veins tend to dip steeply and occupy faults, usually tensional and diagonal shear zones formed as secondary openings in connection with large wrench or strike-slip faults. Half of the primary gold mineralizations occur in fractured alltration zone in igneous intrusions of mainly granitic to dioritic compositions. Exeptionaly, better resources are found were intrusions are cut by shear zones.

Most of gold deposits are associated with igneous intrusions rather than faults due to the association of the gold-bearing magmatic solutions with the intruded igneous stocks and the accommodation for of the gold-bearing solutions provided by the resulting minor faults and fractures. Faults are crucial to the passage and accommodation of these solutions. Gold deposits associated with faults are located within the vicinity of the major intrusions since they are the source of the rich-gold magmatic solutions.

For a detailed future study, complete tabular dataset for the tonnage and gold concentrations is highly recommended to quantify more precisely the spatial relationship between gold ore, intrusions and faults.

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FIGURES

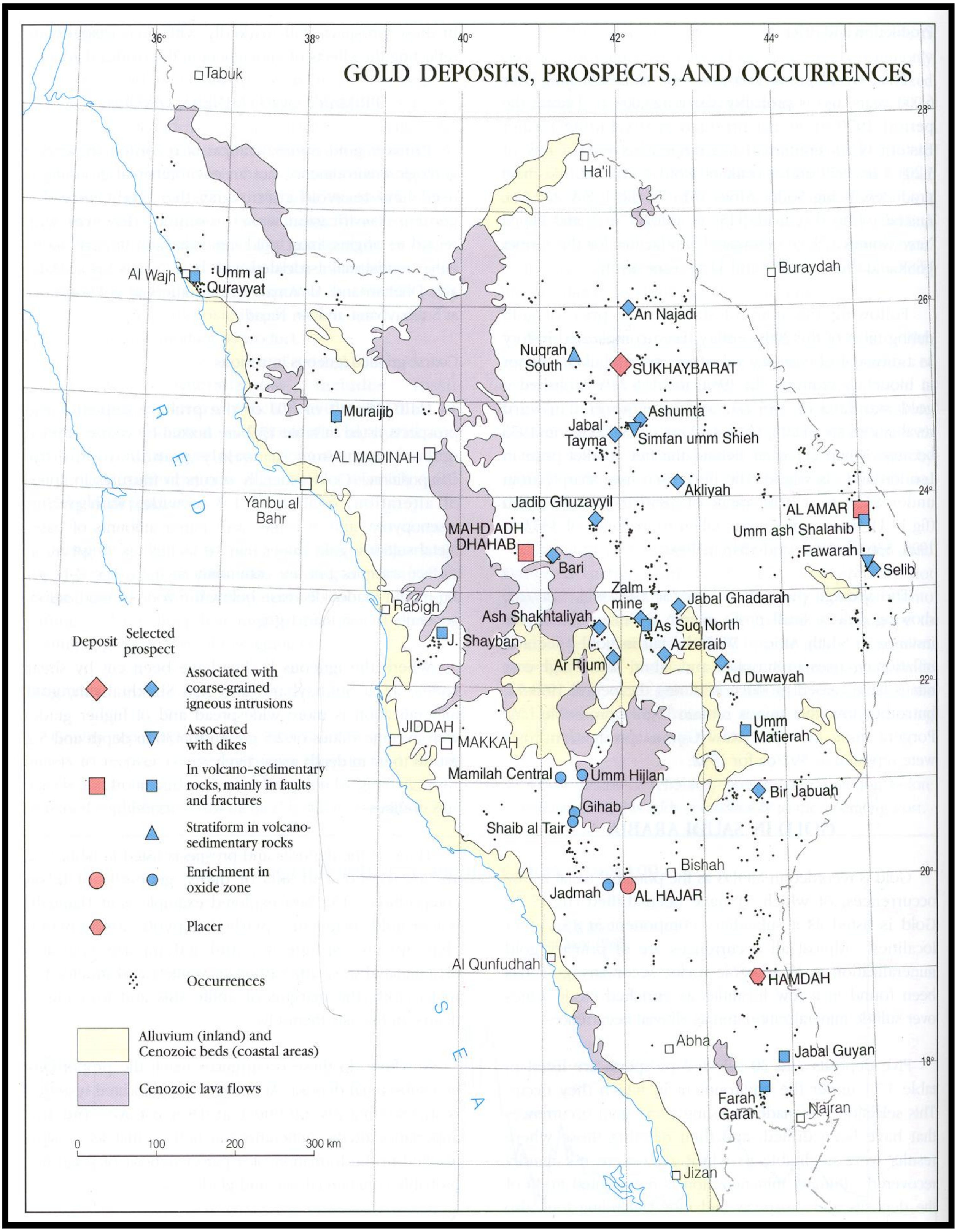

Figure 1. Gold deposits, prospects, and occurrences

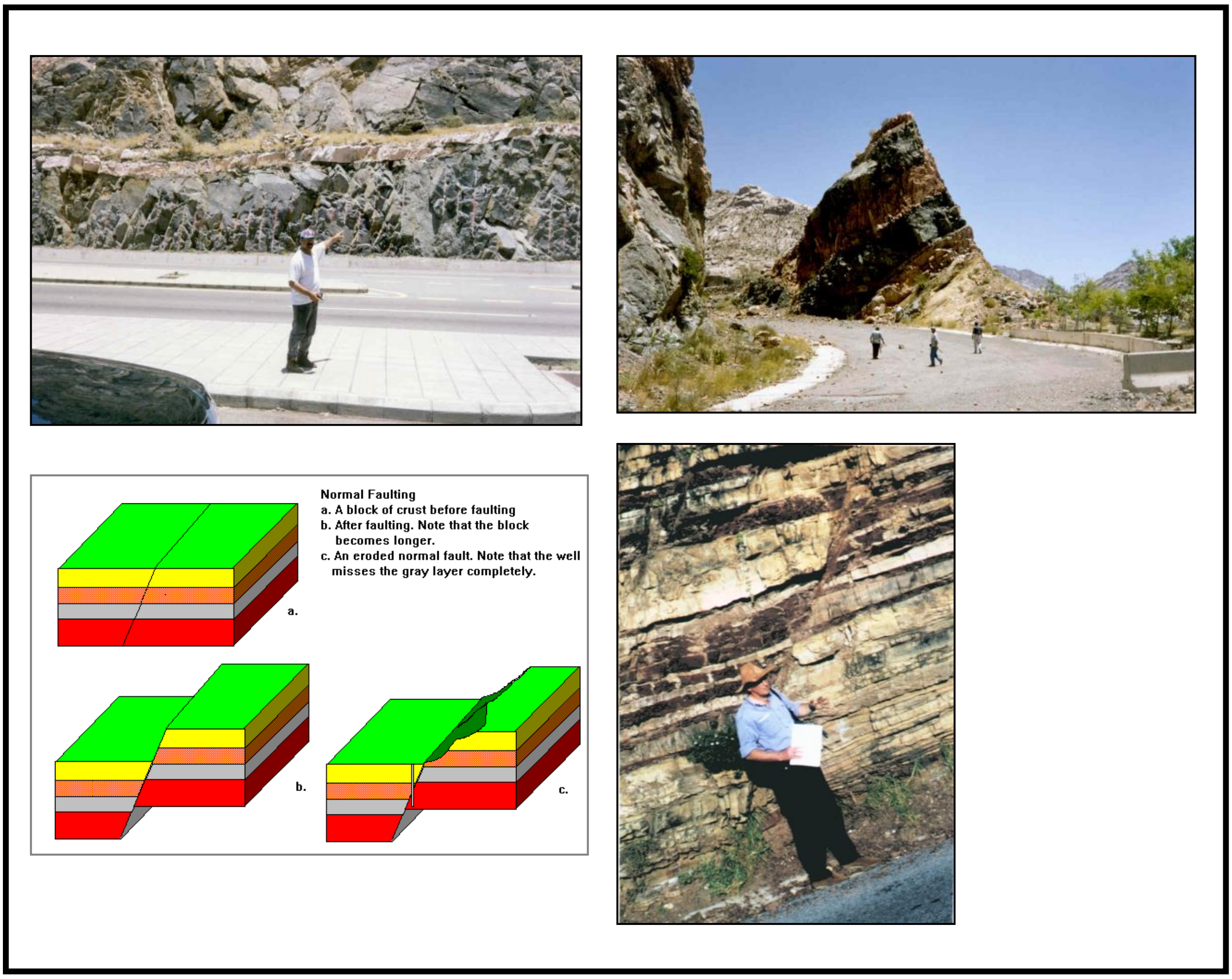

Figure 2. Example of (a) Fault & (b) Intrusion

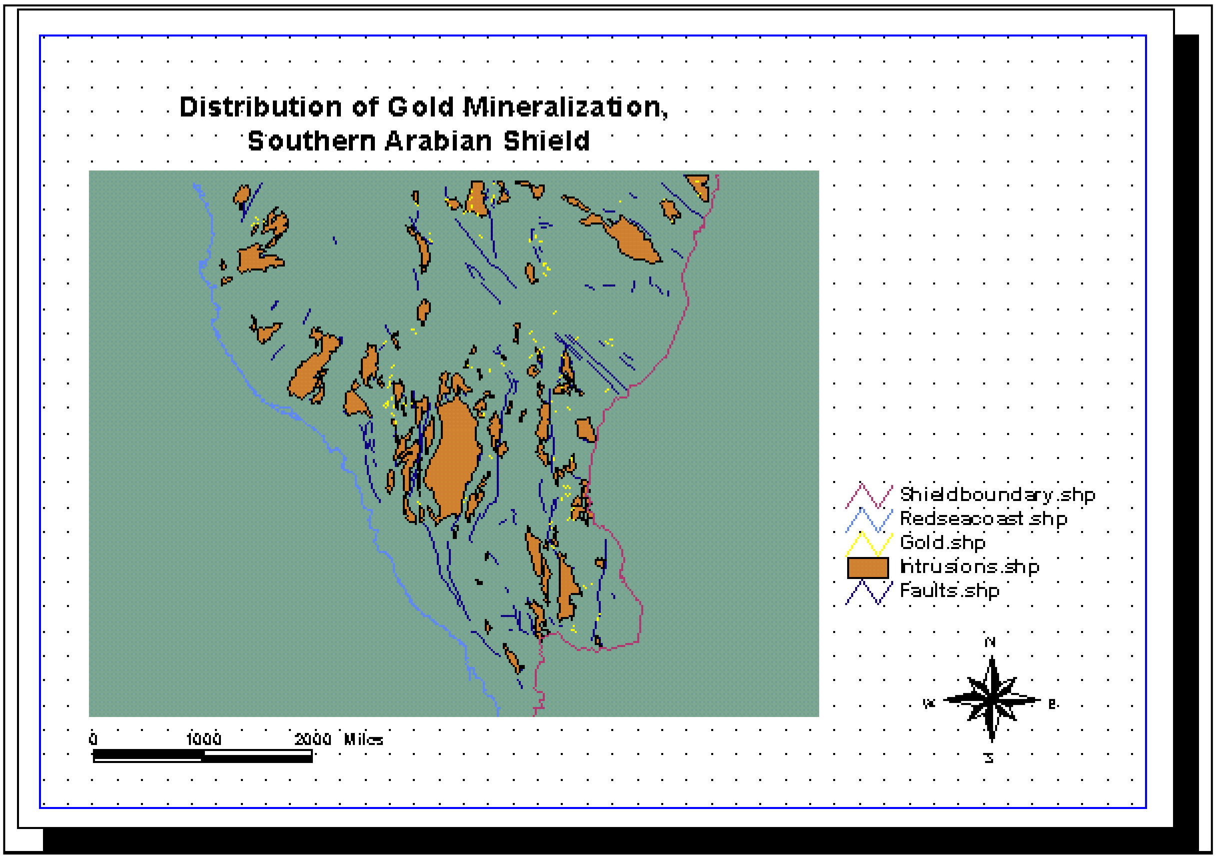

Figure 3. Distribution of Gold Mineralization, Southern Arabian Shield

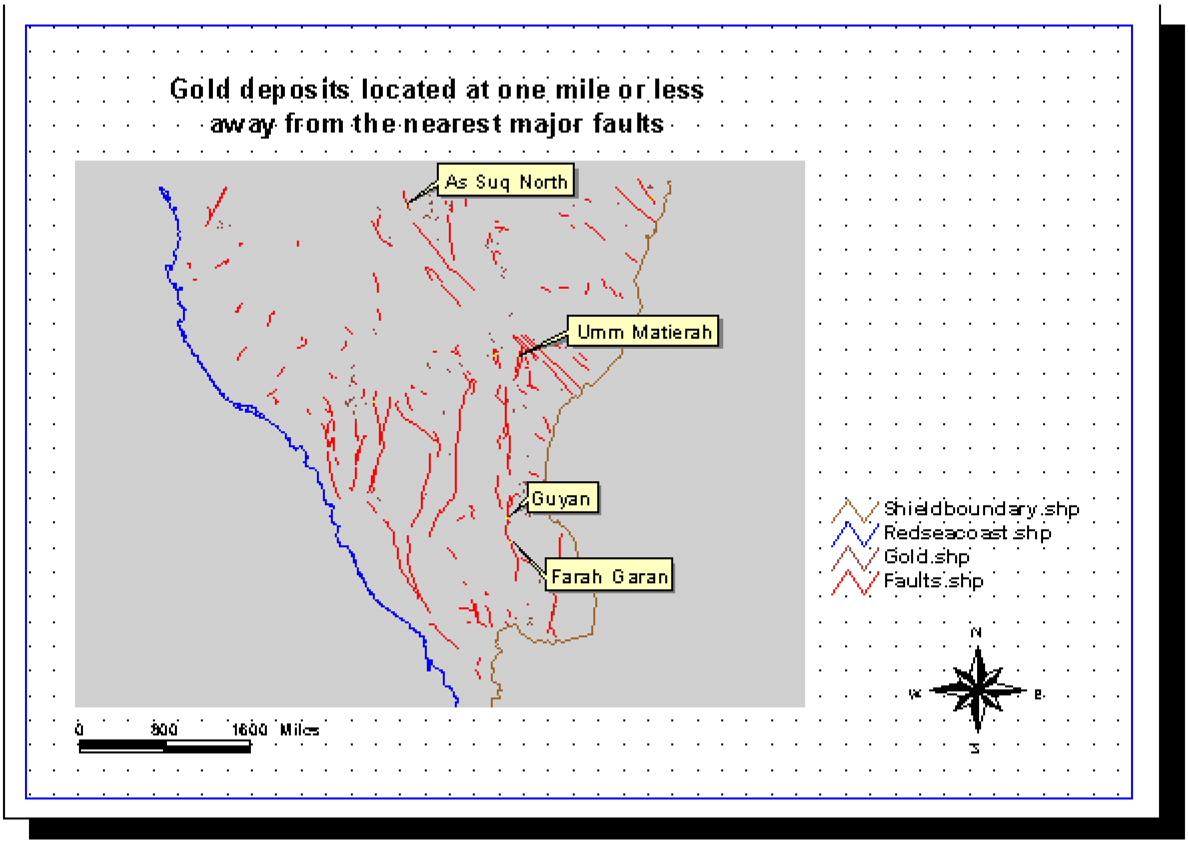

Figure 4. Gold deposits located at one mile or less away from the nearest major faults

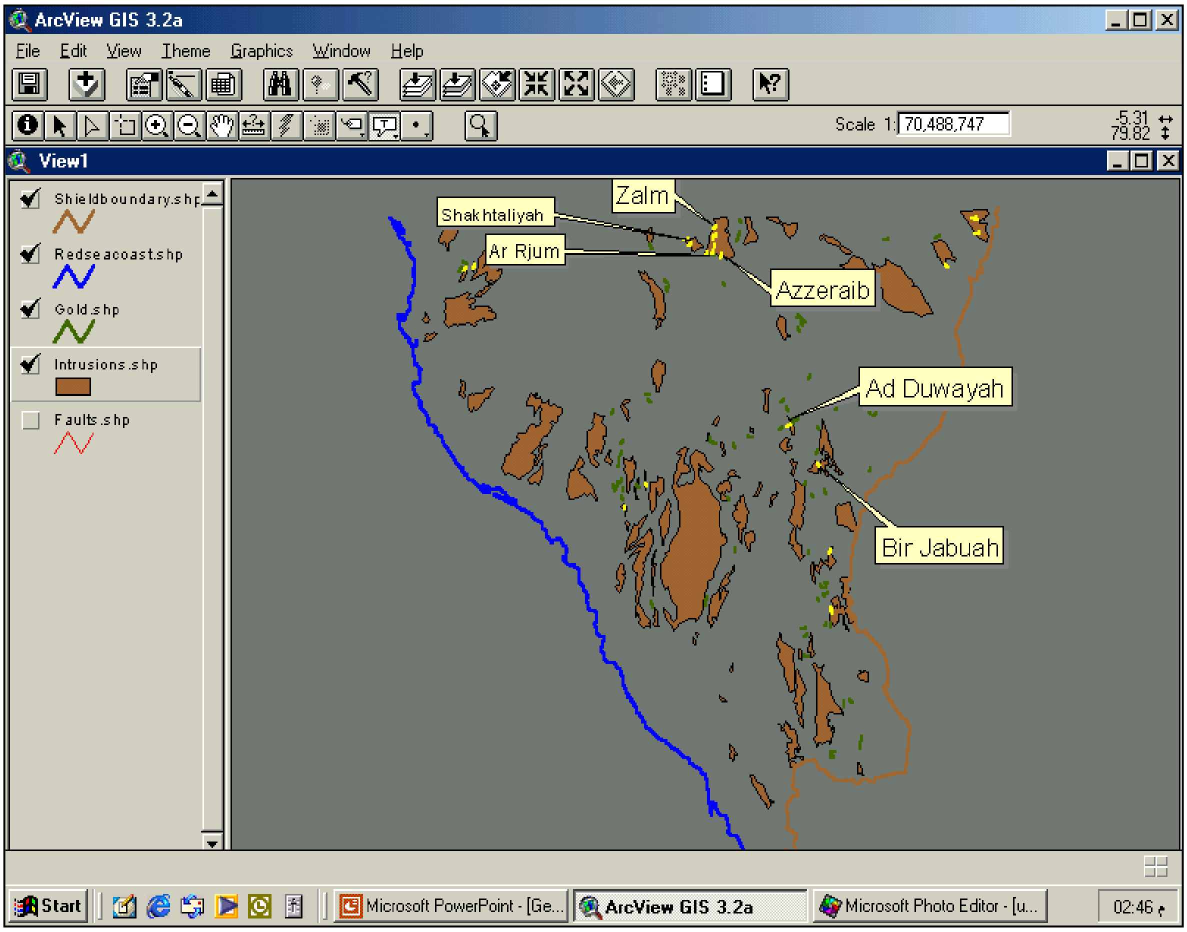

Figure 5. Gold deposits located at one mile or less away from the nearest Intrusions

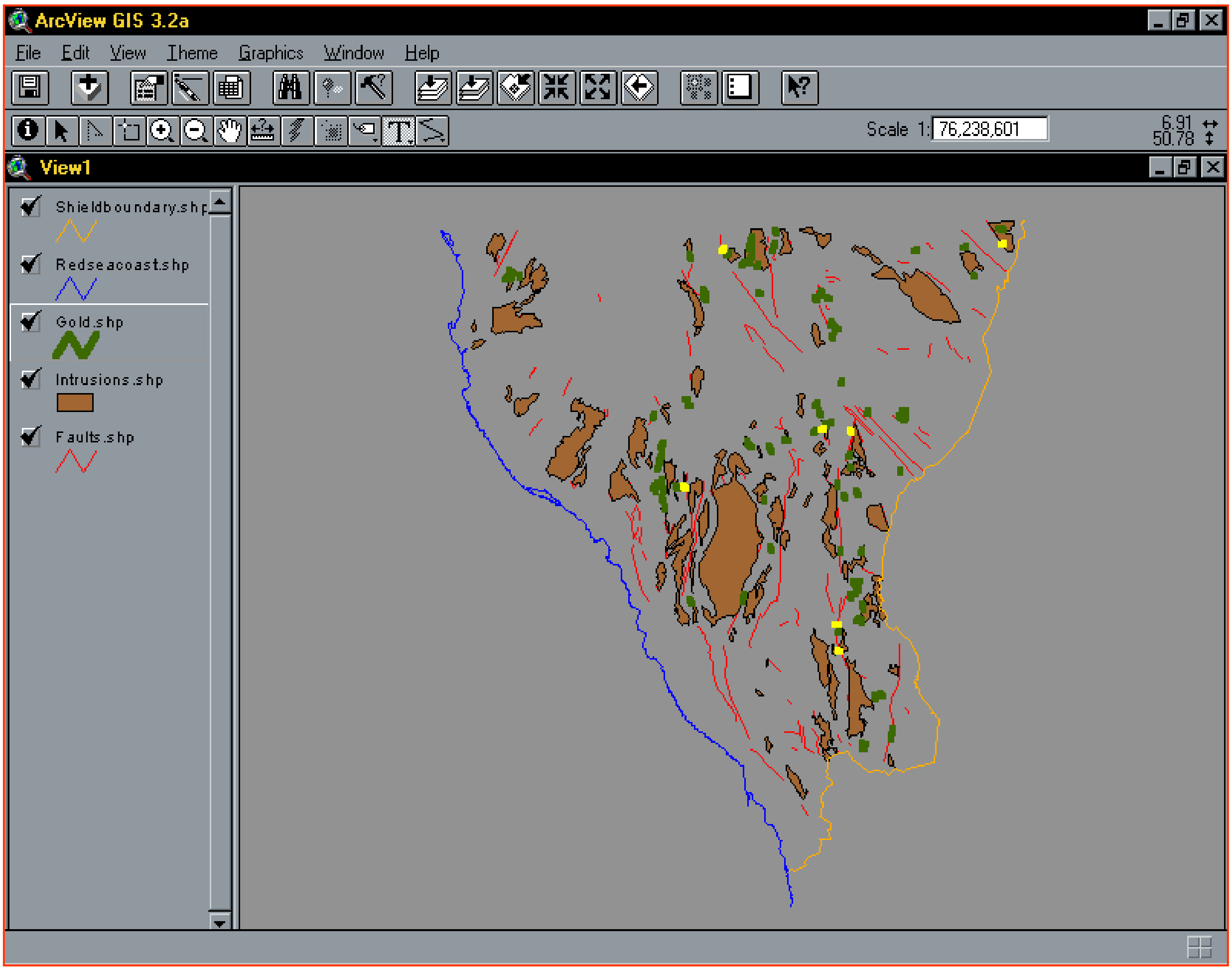

Figure 6. Most of the Gold deposited with faults are adjacent to major intrusions

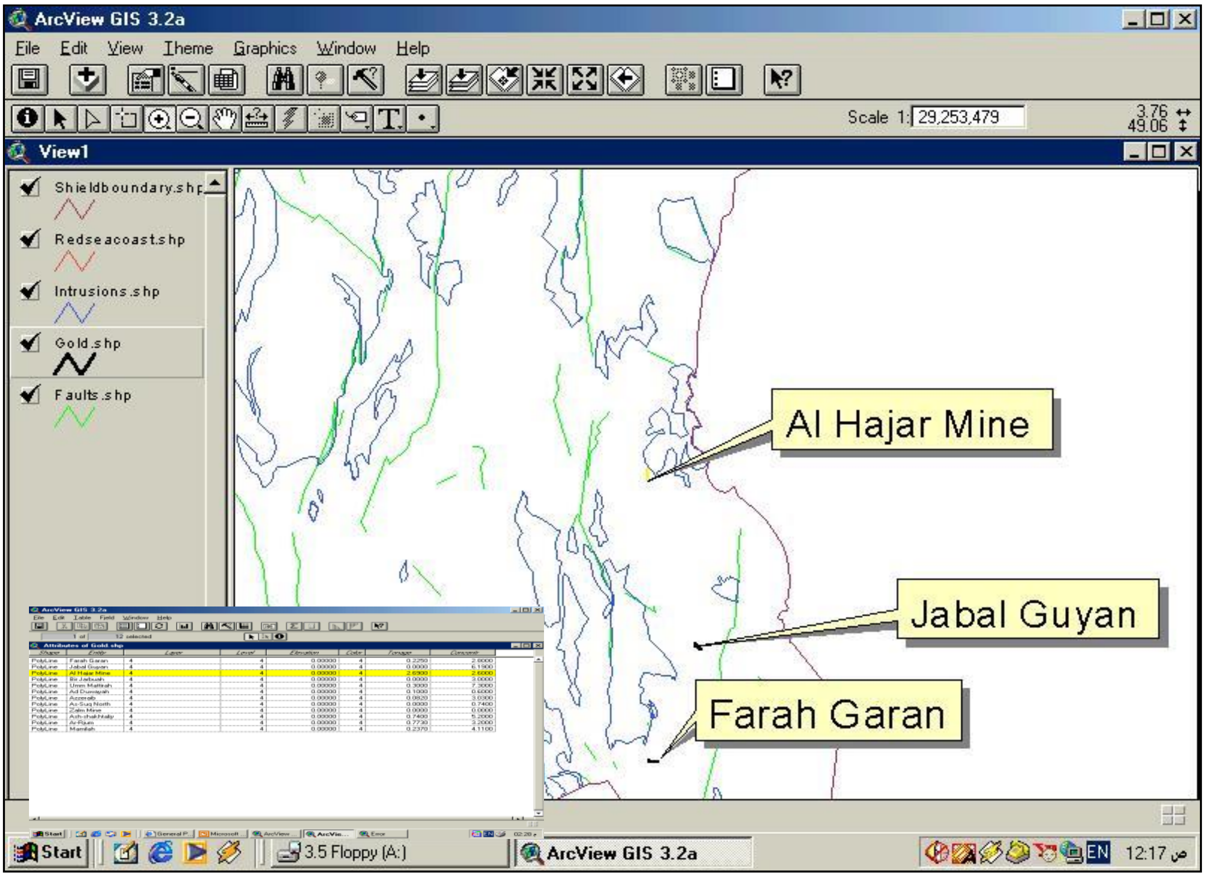

Figure 7. The highest – tonnage mine is located very close to an igneous intrusions

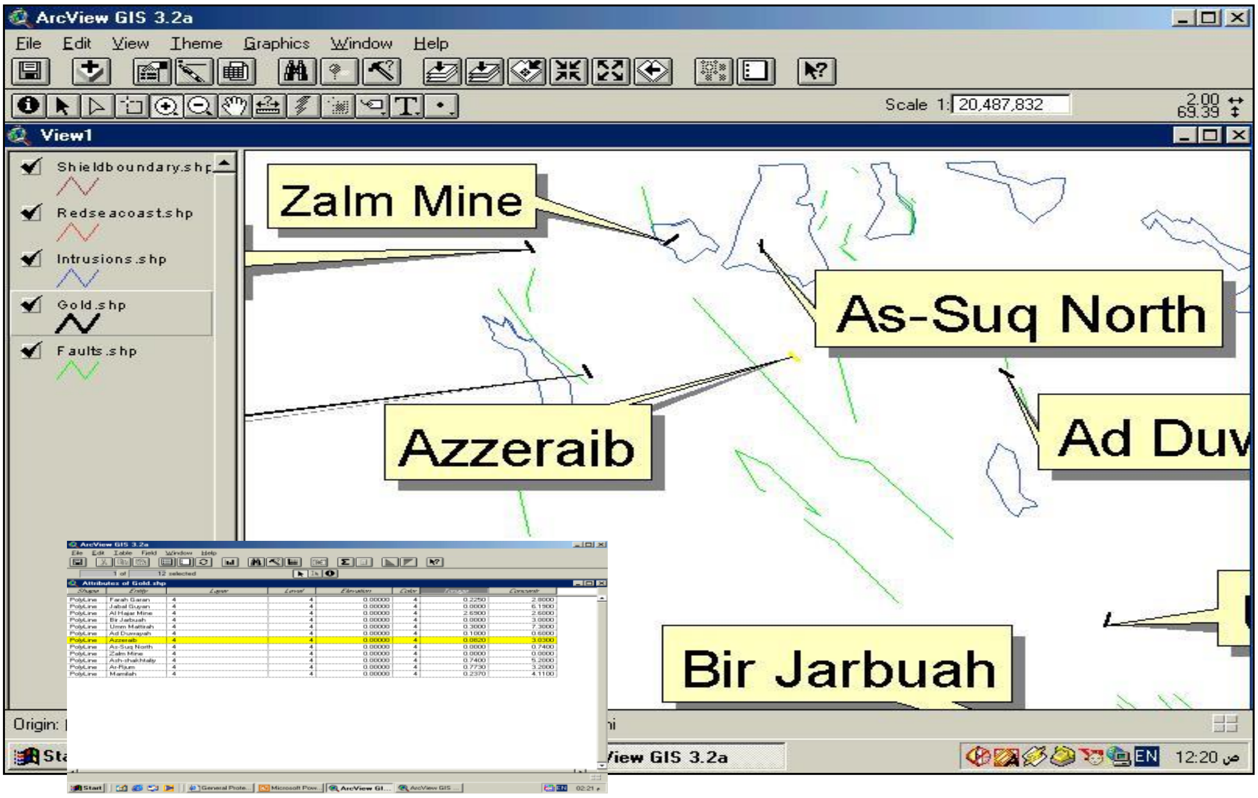

Figure 8. The minimum – tonnage mine is still obviously far from the nearest intrusions and faults