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Use of the GIS (Geographic Information Systems) in Determining Relationship between Geology, Structures and Mineral Prospects, Southern Part of the Arabian Shield, Saudi Arabia

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Abstract: GIS can be utilized in geology in different fields among them; mineral and petroleum exploration, geological mapping and reconnaissance, environmental studies, and in hydrogeological modeling.In mineral exploration the GIS is used to define a set of characteristics of specific mineral deposit that might be used as a guide to similar deposits in the region. An example is being the spatial relation of igneous intrusions and / or geological structures to the mineral prospect locations.This study aimed at using the GIS to find out the relationship of the different geological features through the layers (coverages). These features include faults, intrusions and mineral locations in the Southern Arabian Shield. Coverages (layers) for the digitized material were created using ARC INFO and consequently edited, cleaned and built. Coverages were also imported and exported in order to be read by ARC VIEW. Results of study indicated an excellent association of the faults and other structures to the known mineral locations. Positive correlation can also be concluded from the spatial distribution of the mineral locations and igneous intrusions. These results may imply that igneous intrusions and structural features control mineralizations. The conclusion can help in discovering mineralization in similar geological and structural setting within the Arabian Shield area.

Key Words: Geographic Information, Reconnaissance, Hydrogeological

Introduction

The GIS is used in many fields among them agriculture and land use, monitoring of desertification, forestry and wildlife management, archaeology, city planning, municipal applications and geology. Application of GIS in geology is very broad and diverse. In geology, geological relationship can be determined through spatial characteristics. Based on this concept several data sets can be created and analyzed. Hence, the GIS can be used in geology in different fields among them; mineral and petroleum exploration, geological mapping and reconnaissance, environmental studies and hydrogeological modeling. In mineral exploration the GIS is used to define a set of characteristics of specific mineral deposit that might be used as indicator or pathfinder for similar deposits in the region. Example of such application is the spatial relationship between mineral prospects and both intrusions and structures. In this study the GIS facilities were used to create different layers (coverages) for the geological features such as faults and lineaments and intrusions to find-out their spatial relationships to gold locations.

Geology of the Arabian Shield and its Economic Importance: The Arabian Shield is the basement igneous and metamorphic Precambrian rocks that exposed in the west, northwest and southwest parts of the Arabian Peninsula. It is narrow in the north and south and wide in the middle. The width reaches about 50-100 km in the north about 200 km in the south. Whereas, in the middle the width reaches its maximum of about 700 km (Fig. 1).

The age of the Arabian Shield ranges between (400 - 1000 million year) and some rocks may also date to 2000 million year (Johnson, 1998). The Arabian Shield is a segment of the Nubian Shield, which has been separated in the Early Tertiary by the formation of the Red Sea (Fig. 2). Rock units of the Arabian Shield were subjected to many deformational and metamorphic processes that change most of their characteristics. The Arabian Shield has been divided into eight terrenes; Midyan, Hijaz, Jeddah, Hail, Afif, Hail, Ad-Dawadimi, Ar-Rayn and Asir (Fig. 2; Johnson, 2000). These terrenes were derived from different tectonic settings and amalgamated to each other through fault boundaries. This study mainly focused on the southern part of the Arabian Shield the area between longitudes 39° 00-45° 30 East and latitudes 17° 00-23° 00 North (Fig. 1). It covers major part of Asir trerrane and the southern parts of Jeddah and Afif terrenes (Fig. 2).

The Precambrian rocks of the Arabian Shield accommodate most of the Saudi Arabia's known metal deposits, such as gold, silver, copper, zinc, iron, and magnesium (Johnson, 1998). Most of these metallic minerals are located in the Proterozoic rocks of the Arabian Shield exposed in the western part of the Kingdom (Collenette and Grainger, 1994). Industrial minerals are also located in the Arabian Shield but they are more common in the Phanerozoic sedimentary rocks that flank the Shield in the eastern and northern parts and underlie the Red Sea plain (Fig. 1). Gold is the main metal deposits in the Arabian Shield it is recorded in 782 locations among them 51 have been drilled (Fig. 3; Collenette and Grainger, 1994). Majority of the gold deposits within the Arabian Shield are associated igneous intrusions and sills and as veins and stockworks in faults and fractures (Collenette and Grainger, 1994). Based on this geological association the study focuses on the relationship of intrusions and faults to gold locations. The aim of this research is to determine the relationship and to define the possible criteria of the association of gold locations to intrusions and faults in the Southern Arabian Shield.

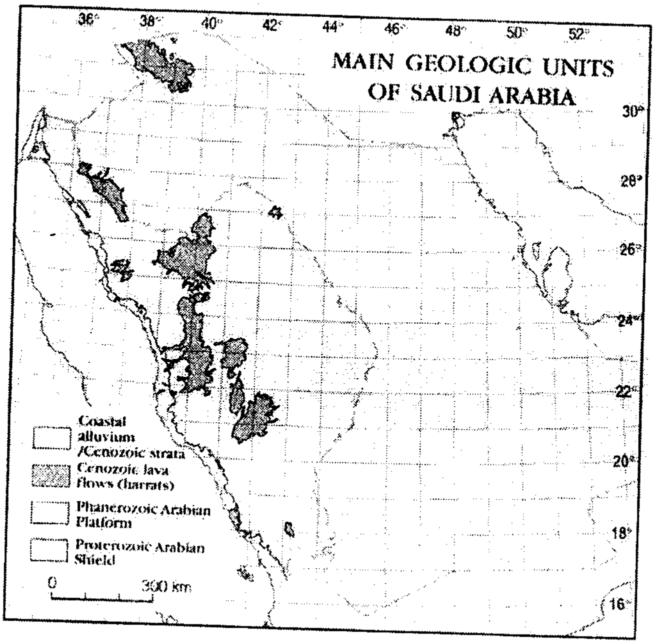

Fig. 1: The Main Geological Units of Saudi Arabia
(From Collenette and Grainger, 1994)

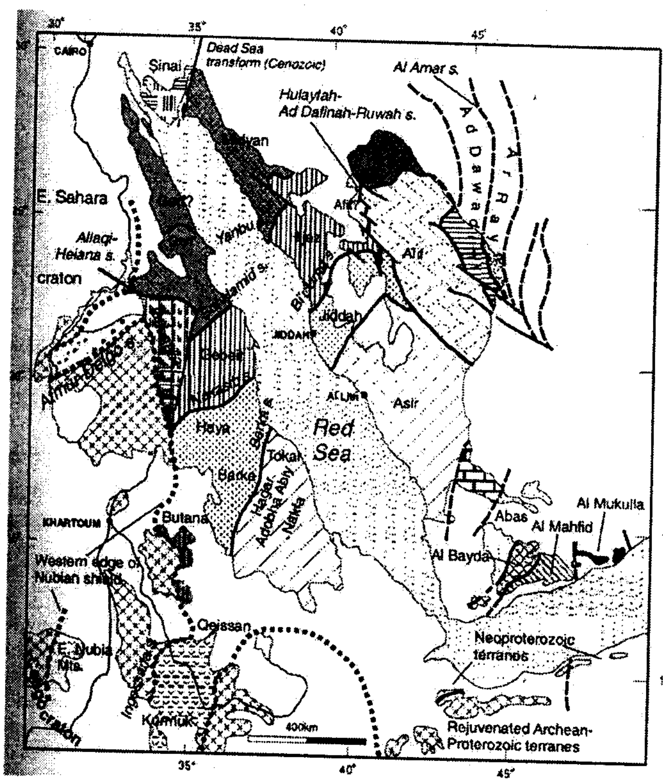

Fig. 2: The Arabian Nubian Shield and the Eight Terrenes
of the Arabian Shield (After Johnson, 2000)

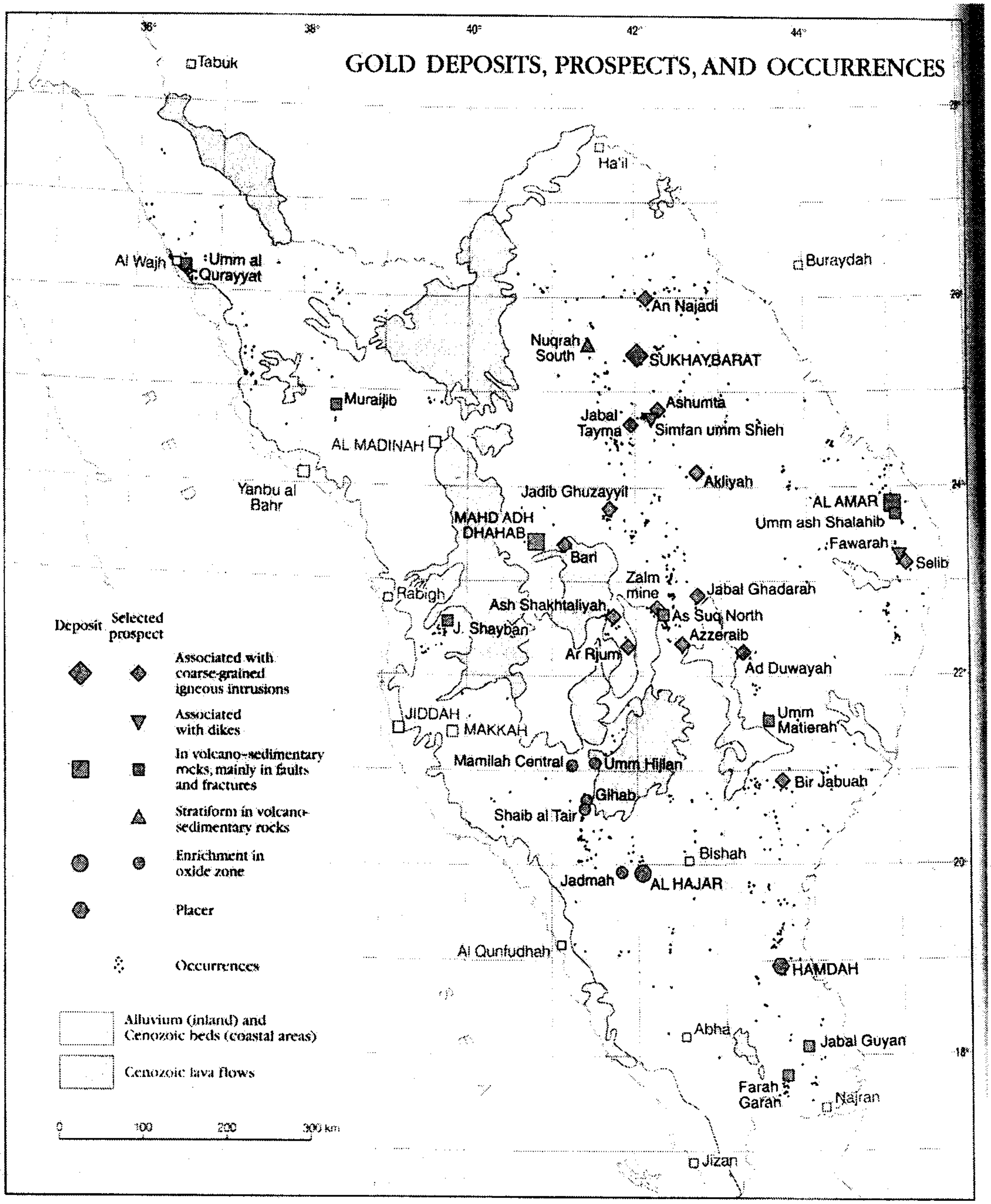

Fig. 3: Location Map of the Gold Prospects and Occurrences within the Arabian Shield (From Collenette and Grainger, 1994)

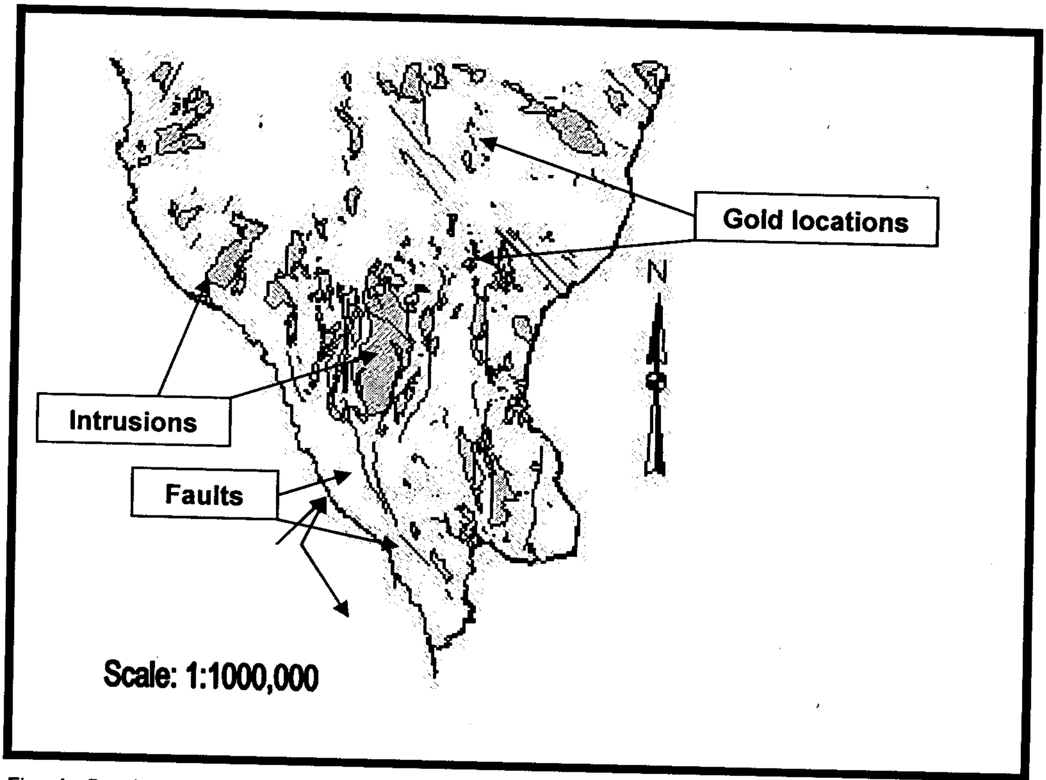

Fig. 4: Combined Layer of Gold Locations, Faults and Intrusions, Southern Arabian Shield

Materials and Methods

Due to the nature of the study it has been divided into three main stages. In the first stage the geological maps were selected and geological features were defined for digitization. The defined geological features were selected based on the geological background and concepts that indicate that there should be a positive relationship between intrusions and mineralization and faults to mineralization. A total of five geological and mineral location maps were selected based on the mentioned principles. Features such as faults, type of intrusions and gold locations in the Arabian shield were also defined on the mentioned maps and selected for digitization.

Several coverages (layers) for the digitized material were created using ARC INFO. In this stage coverages were also edited, cleaned and built. The coverages were also imported and exported in order to be accessed by ARC VIEW (Fig. 4). Gold locations, intrusions and faults were digitized from the map titled Selected Mineral Occurrences of the Arabian Shield South, 1: 1000,000 (Barnes *et al.,* 1986 and Johnson *et al.,* 1986) and a total of three separated coverages were created in the course of this study for intrusions, faults and gold locations (Fig. 4). These coverages cover only the southern part of the Shield area.

Intrusions such as granites, quartz diorite and granodiorite were digitized because of the known association of felsic intrusions and gold mineralization. Structures such as faults, fractures and lineaments were also digitized from the above maps for the same purpose (Fig. 4).

In order to find-out the spatial relationship between gold locations and intrusions and faults in the Southern part of the Arabian Shield the three coverages for each feature were opened as theme. Consequently, the spatial relationship was determined through the selection of the gold locations theme and its relationship to the themes of faults and intrusions. Number of gold locations intersect with, their center within and in defined distances from faults and intrusion where determined and calculated to percentages (Tables, 1 and 2). 2.5 km and 13 km buffers around the gold locations were also created and their spatial relationships to faults and intrusions are determined (Tables 1 and 2). A total of 104 gold locations were used in this study.

Table 1: Summary of the Spatial Relationship between gold Locations and Faults in the Southern Arabian Shield

Criteria	Number out of 104 locations	Percentage
Number of gold locations intersect with fault	97	93.3%
Number of gold locations have their center within fault	97	93.3%
Number of gold location within a buffers of 2.5 -20 km from fault	101	97%

Table 2: Summary of the Spatial Relationship between Gold Locations and Intrusions in the Southern Arabian Shield

Criteria	Number out of 104 locations	Percentage
Number of gold locations intersect with intrusion	102	98%
Number of gold locations have their center within intrusion	102	98%
Number of gold location within a buffers of 2.5 -20 km from intrusion	91	88%

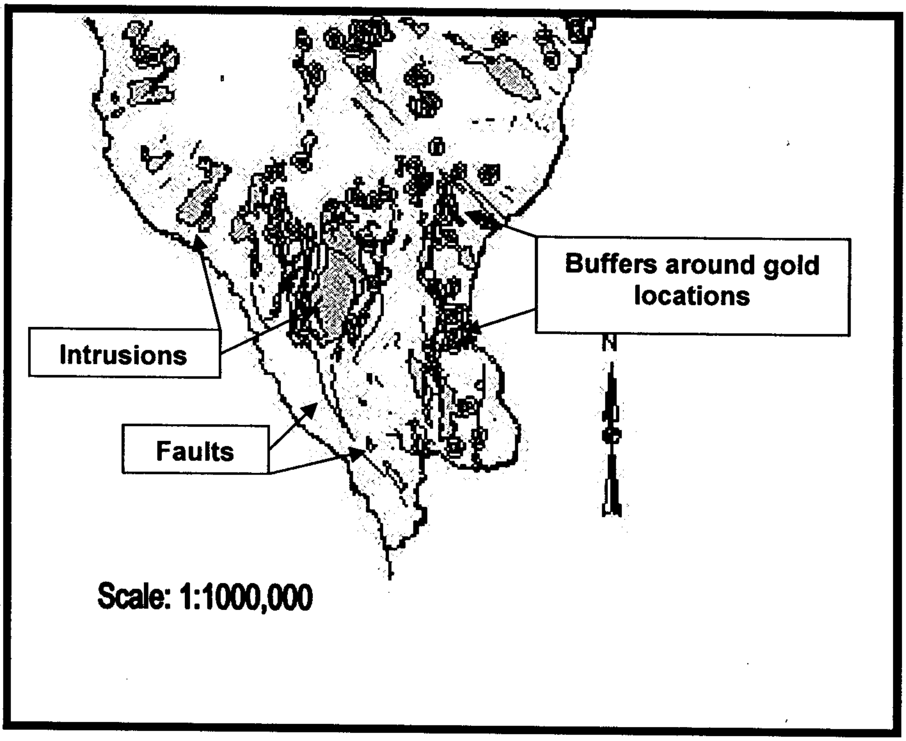

Fig. 5: Buffers of 2.5 Km And 13 Km around the Gold Locations, Southern Arabian Shield

Conclusion

Results of the finding of this study are summarized in tables 1 and 2. Ninety-seven (93%) of the 104 gold locations in the Southern part of Arabian Shield are intersect with or have their center within a fault (Table, 1). Similarly, 97% about 101 of the 104 locations are within buffers of 2.5-13 km from fault (Table 1 and Fig. 5). The intrusions spatial relationships to gold locations indicated that 102 (98%) out of 104 locations intersect with or have their center within an intrusion (Table, 2). However, 91 (88%) gold locations are located within buffers of 2.5-13 km from an intrusion (Table 2 and Fig. 5).

The results of this study indicate that a positive spatial relationship is present between gold locations and structures (faults, fractures and lineaments) and intrusions in Southern Arabian Shield. This relationship is also known and reported geologically for the Arabian Shield and other areas. However, the study also proves that the GIS technique is an effective tool that can be used to determine geological spatial relationship. Moreover, the finding of this study can be extended for exploration purposes to areas within the Arabian Shield or other areas where similar features and conditions are available.

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