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PETROGENESIS OF SEDIMENTARY IRONSTONES IN JABAL SANAM STRUCTURE – SOUTHERN IRAQ

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Abstract

A total of (16) ironstone samples were collected from surface exposures of Jabal Sanam. These samples were firstly described in the field, and then ten thin sections prepared for microscopic study. X-ray, U.V. visible and atomic absorption was employed .The available ironstones show a wide spread distribution over Jabal Sanam structure mainly in the eastern and southeastern parts. Their variety coulors; brown to reddish brown, yellow to reddish yellow, depending upon the Fe^{+3} Oxides State the content characterize them. The ironstones under study have high percent of Fe^{+3} about 52% , the obtained X-ray and ultraviolet diffraction patterns and atomic absorption revealed the dominancy of Hematite mineral. It's believed that these ironstones originated by the decomposition of Precambrian basement: basic, ultra basic igneous and metamorphic rocks by the action of hydrothermal solutions that accompanied the peircement of Jabal Sanam**.**

Introduction

The iron sedimentary rocks or iron rich deposits refers to those rocks which predominantly consist of iron minerals subordinate amounts of oxi-hydroxides, carbonates, silicates and sulphides (Friedman & Sanders, 1978). Sedimentary ironstones are found in the nature in three major forms: ironstones, iron formations and bog-iron deposits (Pettijone, 1975). These rocks contain many types of iron minerals as shown in table (1). Iron exhibits a wide patterns range from minor to major components to seldomly concentrated (15%) from ironstones and iron formations (Tucker, 1982).

Table.1: - The main types of iron minerals in ironstones (Tucker, 1982).

Minerals groups	*Iron minerals*	*Fe-proportions (%)*
Oxides	Hematite (Fe_2O_3)	30-60
	Magnetite (Fe_3O_4)	48-68
	Goethite (FeO.OH)	25-65
	Limonite($FeO.OH.nH_2O$)	20-55
Carbonates	Siderite($FeCO_3$)	25-40
Silicates	Glauconite [$KMg(FeAl)(SiO_3)_6.3H_2O$]	30-50
Sulphides	Pyrite(FeS_2)	64
	Marcasite(FeS_2)	

Several studies were conducted on Jabal Sanam these studies confirmed the occurrence of iron deposits in different types of rocks. This study is an attempt to distinguish the separation of these rocks, then to identifying the iron mineral types, as well as the determinations of the sedimentary conditions of Jabal Sanam iron rocks.

Geological Setting

Jabal Sanam is a relatively small isolated prominent hill (plate,1) rising about (152m) above see level of dimensions 1.7km long and 1.5km width near Iraqi-Kuwait borders and about (45km) south west of Basrah city (fig.1). All previous studies focused on this structure agreed that Jabal Sanam is caused by salt dome or plug injected within the sedimentary cover salt beds rising inversion mechanism (Al-Naqib, 1970; Kent, 1987; Al-Muttory, 2002; Soltan, 2002).It's believed that Jabal Sanam represents an oval structure during Miocene (fig.2) with very complex faults and joints systems which influence extremely the lithological and structure settings.

The field observations confirm the presence of three main lithological units; the first is a core of broken and fractured dolomite, dolomitic limestone and silty-muddy limestone rocks (dolomite unit) surrounded and covered by large unit of gypsum (gypsum unit) and finally a unit of brecciated muddy-silty-gypseous limestone (brecciated limestone unit) (Soltan, 2002) (fig.3).

The dolomitic unit of the core ranges in coulors from dark brown, dark gray to light pinkish gray, which characteristically are laminated. The observed fractures have been filled with secondary minerals permeated the pore spaces of much of the rocks as well (Al-Hamadani *et al*., 2005) .Like other salt plugs structures, Jabal Sanam survive the high intensity of deformation causing the dislocation of many beds ,So it's very complicated to establish a Stratigraphic sequence, nevertheless Al-Naqib (1970) followed by Soltan (2002) arrived to achieve such sequence (fig.3).

Although there are many exotic rocks in the lithological composition of Jabal Sanam represented by a huge rock diversity like chert, marl, silt stone, sandstone, large bodies of dolerites igneous rocks and some metamorphosed rocks like slate, marble, quartzite and greenstone (Soltan, 2002). It is suggested that the age of these rocks is Pre- Infra Cambrian stratigraphically; it’s believed to be related with Hormuz evaporites series (Buday & Jassim, 1987; Soltan, 2002).

Owen & Nasir (1958), Al-Naqib (1970) & Kent (1987) confirmed the presence of mineralized iron oxides bands with shiny crystals (Possibly hematite) spread over parts of Jabal Sanam. Soltan (2002) showed that the Fe content of Jabal Sanam ironstones ranged between 30-95%.

Methodology

A total of sixteen ironstone samples were collected from nine stations in the structure, these samples were firstly described, then 11 lithological thin sections were prepared from selected samples of them. X-ray technique was employed on one of these samples to support the petrographical study and chemically analyzed by using U.V.-visible spectroscopy, atomic absorption and some other quantitative chemical techniques like titration method to identify and calculate the type and the weight percent of iron minerals in these samples.

Petrology

The sedimentary ironstones are characterized by their wide distribution in Jabal Sanam especially in the eastern and southeastern wards (fig.2). The most interested type of these rocks found as thin mineralized bands or lamellas (plate.2, 3).

It is concentrated in the core of the structure inter layering beds of the dolomite unit, Moreover these lamellas characterized by its flaky shapes,

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shiny and metallic luster (plate, 4) with brown to reddish brown- yellow to reddish yellow coulors arrived in thickness to 2cm which contain high ratio of iron oxides as a hematite mineral as proved by X-ray test (fig.4) with dark gray coulor and reddish brown streak.

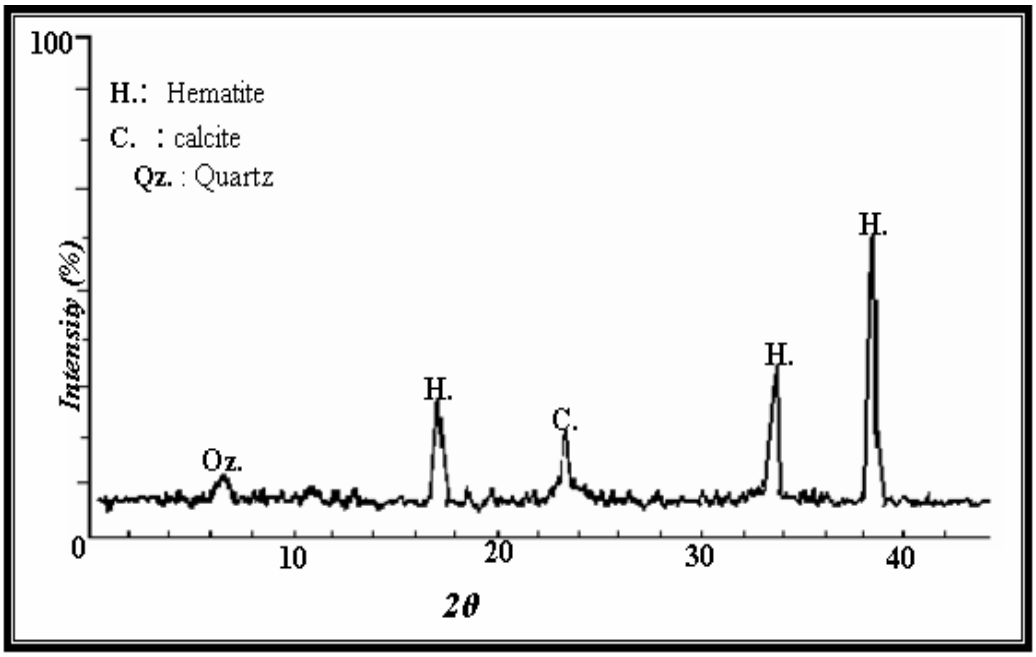

Fig. (4) X-ray analyses result of the collected ironstone sample

The other types of iron deposits mainly occur as variable thickness veins of iron oxides crossed via the different lithological units of Jabal Sanam especially in gypsum unit. Sometimes, the iron minerals or deposits can filling the pores and cavities within the deposits, or coated over the clastic grains causing dark to light coulors of brown, red, yellow stain of iron oxides in these sediments depending upon the amount of the Fe-adsorbed.

Mineralogical examination of iron deposits under study revealed the presence of black hematite opaque crystals, which are lamellas or longitudinal in shape (plate.4), these crystals have a crushed edge sometimes.

In other cases the crystals contains scattered eu-subhedral inclusions of quartz & calcite as inclusion. Few samples show oriented microcrystalline textures related to the external stresses (compressing forces) build up during geological history (plate.5). Furthermore, these rocks contain other

subordinate minerals like dolomite, chlorite and serecite…etc as minor component (plate.5). The other iron deposits found as cementing materials hold the clastics grains (plate.6) or as interstitial channel filling of red or brown iron oxides.

Geochemistry

The collected samples were analyzed following the Alexeyer's (1971) analytical method. Many quantitative chemical tests were performed on these samples to distinguish the major element on it.

These tests showed that the major and characteristic element in the samples was Fe^{+3} which give the solution dark brown coulor when treated with KSCN solution and hydrofluoric acid respectively, on the other hand, there isn't any evidences to fined other important ions. Ultra violet visible spectrum ray was determined using Nir-vist tool on the range between (200-800 nm) which showed the results listed in table (2).

Table.2: Wavelength and resulted absorpance values in U.V. -visible technique.

Wave length (nm)	Absorpance	Wave length (nm)	Absorpance
200	0.3	500	2.5
250	0.8	550	2
300	1.2	600	1.5
350	1.6	650	1.0
400	2.5	700	0.5
450	3	750	0.4
480	3.2	800	0.2

When plotting the relation between wavelengths against absorbance values it gives on maximum value in the wavelength (480 nm) (fig.5) which can be assigned (Fe^{+3}) ions (Vogel, 1967).

To determination the concentration and percent of the sample the spectroscopy method was used .The concentration of Fe-ions in the samples which determined was found about (130ppm) and in weight percent about (52%). Based on the results of atomic absorption spectrophotometer the concentration of ferric ions (Fe^{+3}) in the sample was calculated more accurate which was about (129.1ppm) and the Fe^{+3} ionic percent was (51.64%).

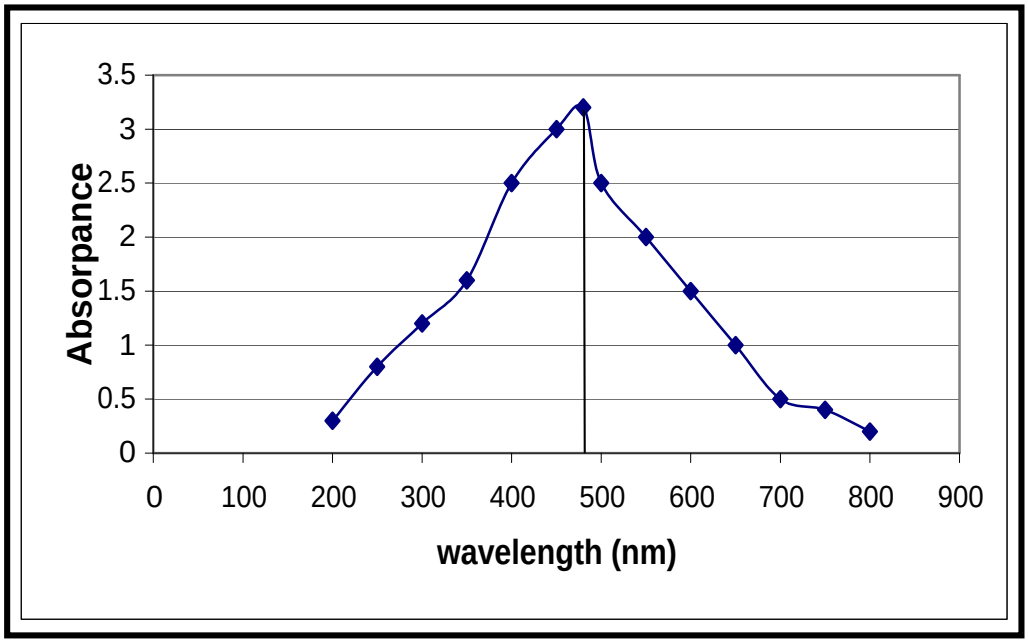

Fig.5:Wave length versus absorpance curve for the collected sample.

Origin of Jabal Sanam Sedimentary ironstones (Discussion & Conclusions):

The types and patterns of ironstone occurrences in nature were studied in detail by many researchers owing to the importance of these rocks as a source of iron ores; Generally speaking the ironstone could be categorized in to two major groups.

1. *Precambrian iron formations*: Where the bedding types of hematite always found interbedded with chert rocks as thin beds or lamellas (Ashley *et al*., 1998). The chert exhibits a variable thickness about hundreds or tenths of meters or as blocks or sometimes spherulitic shapes. In the other hand, these rocks could be divided in to two subgroups: -

A. *Algoma type*: It represents the oldest Precambrian type of iron formation stones which ranges in age between (1800-2600 M.Y.) ago. It's characterized by its occurrence as lenticular beds about some kilometers along and it's always compose of gray to reddish chert with lime beds rich in hematite, Siderite and other ferric silicate minerals. This type is abundant in island arcs accompanied with high volcanic activities, which are, believed the main Fe-enrichment (Pettijon,1975; Lottermoser & Ashley, 1996).

B. *Superior type*:- this type assemblage is commonly associated with clastic sediments in shields and miogeosyncline zones like quartz claystones. It seems to be not related with volcanic activities. This type shows regional extant cover about (1500 km) in the middle late Precambrian. The source of iron in these zones could attribute to the deep erosion of continental crust.

Both types of iron formations characterized by thin bedding or banding with thickness ranges between (1mm) to some centimeters, which contain one or some rich minerals as oxides, silicates and carbonate or other forms and absence of any relics of organic materials (Kimberly, 1989).

2. *Phanerozoic ironstone*: This ironstone found as oolitic hematite beds having about 8m thickness (Blatt *et al.*, 1980), fossils remains are abundant in these rocks were replaced partially or completely by hematite. The hematite occurs as cementing materials between mineral grains or bioclastics. It is believed that the iron derived from groundwater rich in Fe-ions, which is derived from the activity of chemical erosion to the continental rocks (Tucker, 1982; Ashley *et al*., 1998).

Based on the above information and after petrological comparison with the Jabal Sanam ironstones, it is believed that the available bedded ironstone could belong to the second subgroup of iron formations (*Superior type*) and it comes derived from high extensive alteration processes of Pre-existing basic, ultra basic igneous and metamorphic rocks of basement complex in the deeps. These alterations have been occurred, before millions of years, in the presence of high pH and strongly positive oxidation (+Eh).The latter conditions product this high percentage of hematite (Mason & Moore, 1982) (Fig.6).

These Iron rich sediments firstly deposited in shallow lagoonal environment side by side with evaporites & carbonates rocks forming Hormuz salt series during Precambrian period, later these ironstones & the some basement rocks were influenced by faulting, deformation and hydrothrmal solutions through the processes of evolution of Jabal Sanam salt structure. These salts fragmented and altered the rocks by the action of thermal ground solutions which were transport Fe-ions, then reprecipitated it later within the different forms of rocks in Jabal Sanam as veins or thin beds or inter sediments materials through many stages of geological history like many cases of salt domes rocks globally (Saurders & Thomas, 1996).

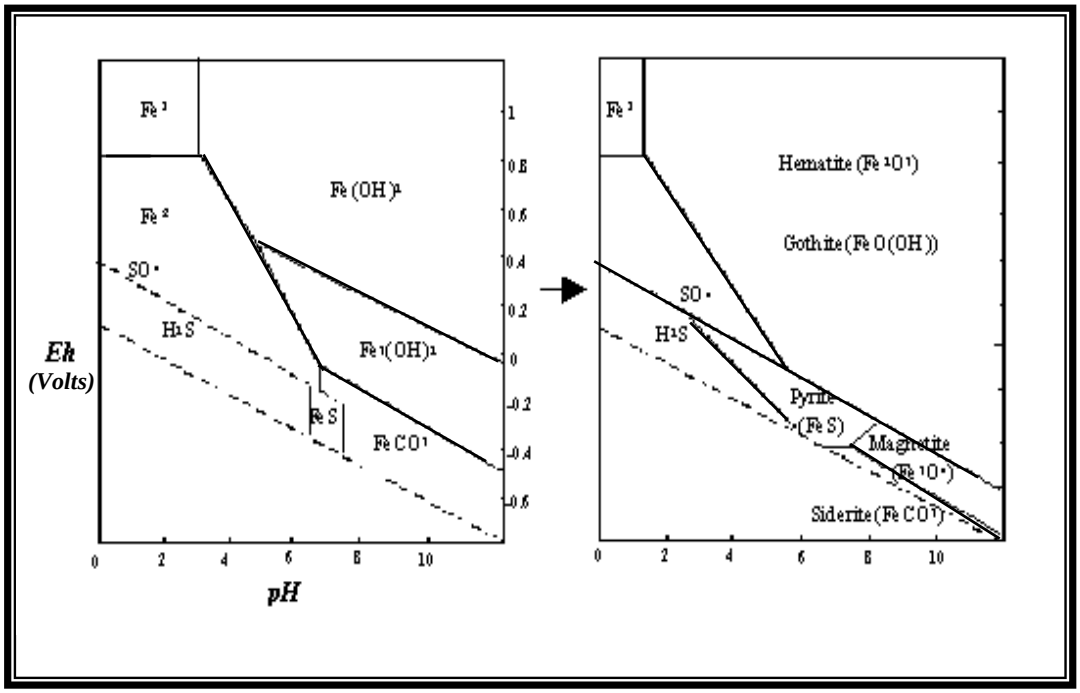

Fig.: 6 The relationship between pH & Eh conditions and formation of variable kinds of iron minerals in the nature (after: Mason & Moore, 1982)

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منشأية صخور الحديد الرسوبية في تركيب جبل سنام _ جنوبي العراق

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المستخلص

ستة عشر نموذجا من صخور الحديد الرسوبية جمعت من المكاشف الصخرية في تركيب جبل سنام، فحصت المواصفات الطبيعية لهذه الصخور حقليا ومن ثم درست مجهريا بعد أن هيأت عشرة شرائح صخرية لها. حللت العينات النقية بصورة تفصيلية بعدة تقنيات أهمها تقنيات الأشعة السينية الحائدة والأشعة فوق البنفسجية والامتصاص الذري وطرق تحليلية أخرى بغية تحديد نوع ونسبة معادن أكاسيد الحديد المشكلة لهذه الصخور. صخور الحديد في جبل سنام امتازت بانتشارها الواسع وخاصة في الأجزاء الشرقية والجنوبية الشرقية من التركيب وبأنها ذات ألوان مختلفة تراوحت بين البني إلى البني المحمر أو الأصفر إلى الأصفر المحمر تبعا لنسب أكاسيد الحديد التي تحويها، وكانت تحوي تراكيز عالية من الـ(Fe^{+3})تصل إلى ٥٢% . بينت نتائج التحليلات المختبرية المختلفة سيادة معدن الهيماتايت في هذه الصخور بصورة رئيسة. ويعتقد أن مصدر هذه الترسبات الحديدية جاءت من تحلل الصخور النارية القاعدية وفوق القاعدية والمتحولة المشكلة لصخور معقد القاعدة البريكامبيري في المنطقة نتيجة لفعاليات المحاليل تحت السطحية على صخور تركيب جبل سنام قبل وأثناء عملية اختراقه نحو السطح.

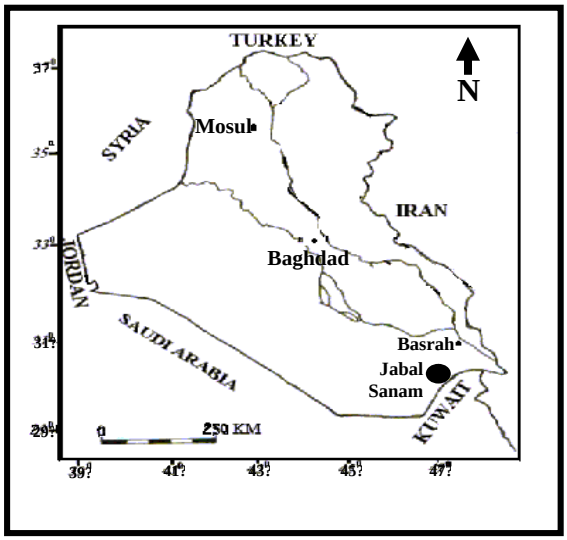
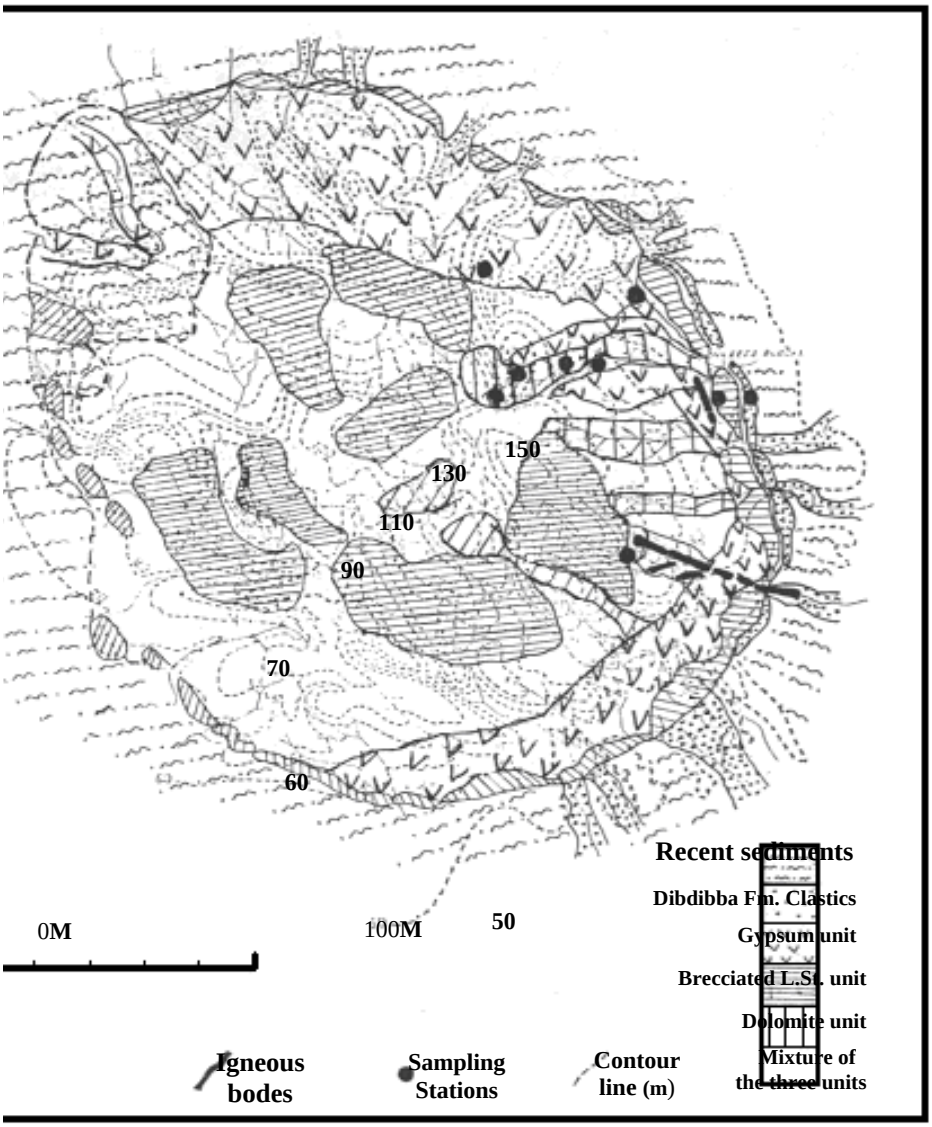


Fig.1 Jabal Sanam location sauthern Iraq

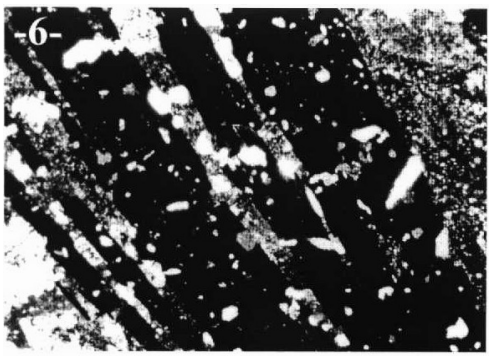


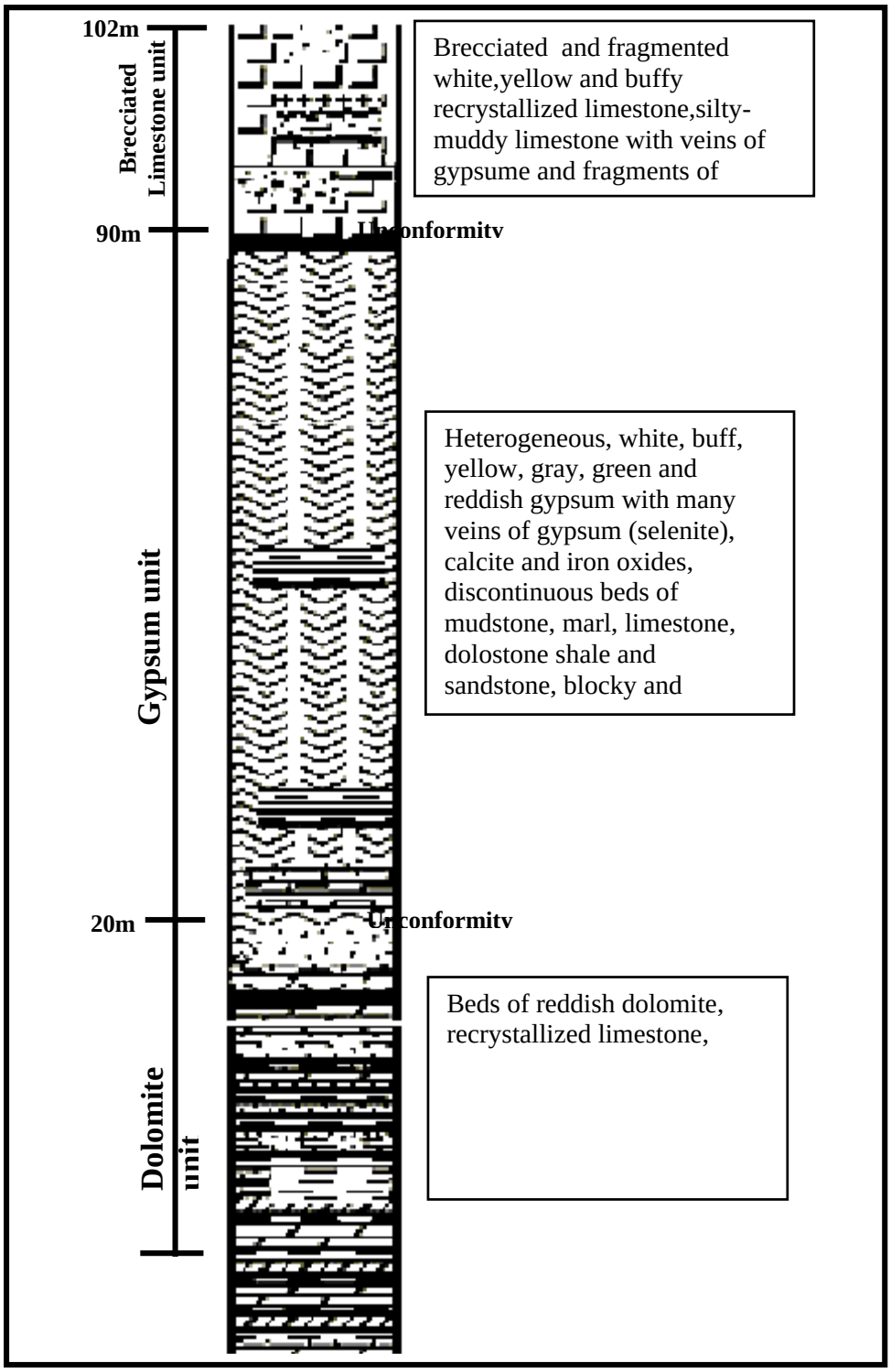
p.3. Ironstones beds in dolomite unit.

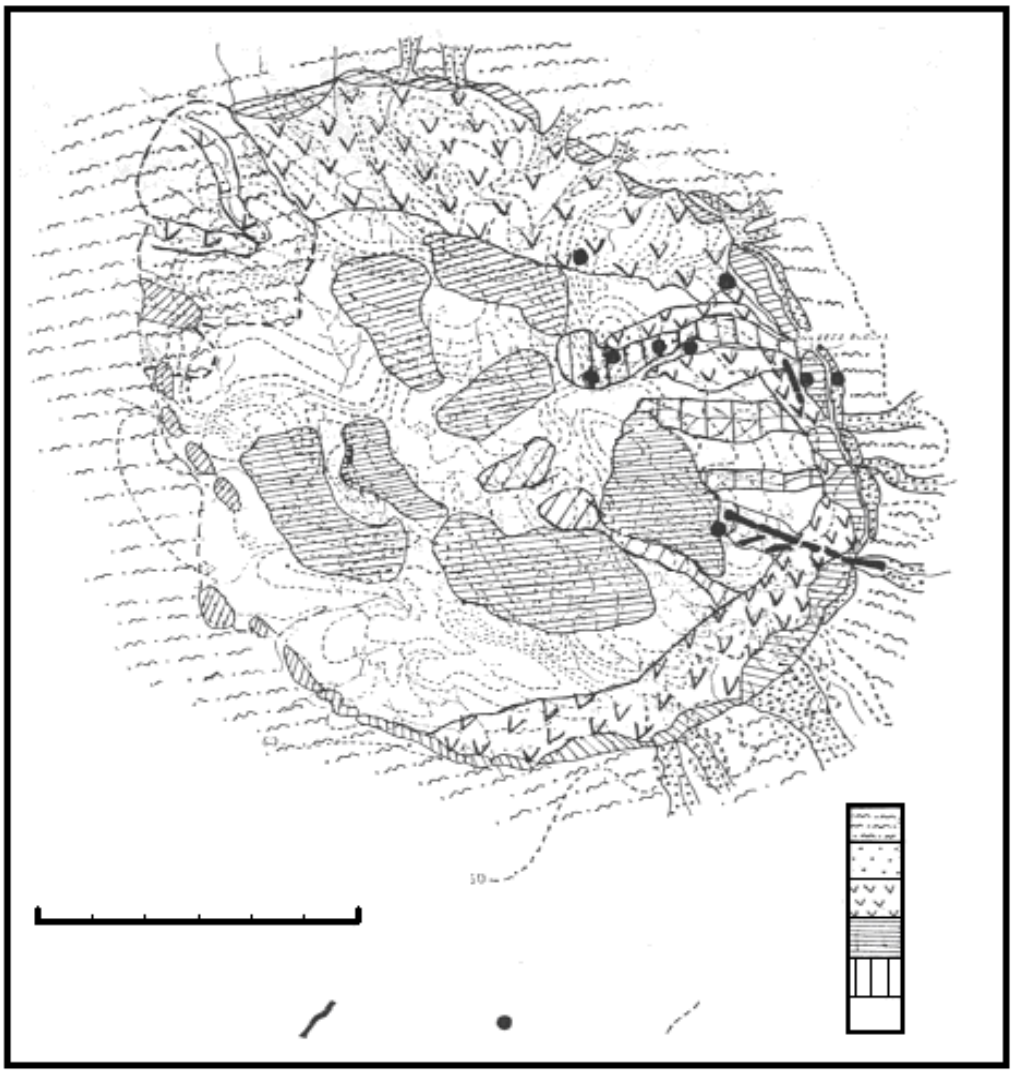
p.4. Specimens of ironstones (a.part of iron bed b. part of iron vein).

p.5. Longitudinal opaque crystals of Hematite (the shiny inclusions is Qz., Calcite, Dolomite as poikilitic texture) **(100.XPL).**

p.6. Iron cementing materials between grains of Qz., fld., chert, calcite (shiny)**(100XPL)** .




102m
Brecciated Limestone unit
90m
Unconformitv
Gypsum unit
20m
Unconformitv
Dolomite unit
Brecciated and fragmented white,yellow and buffy recrystallized limestone,silty-muddy limestone with veins of gypsume and fragments of
Heterogeneous, white, buff, yellow, gray, green and reddish gypsum with many veins of gypsum (selenite), calcite and iron oxides, discontinuous beds of mudstone, marl, limestone, dolostone shale and sandstone, blocky and
Beds of reddish dolomite, recrystallized limestone,



منشأية صخور الحديد الرسوبية في تركيب جبل سنام _جنوبي العراق

المستخلص

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