



Facies Analysis and Depositional Environments of Khabour Formation/ from Iraqi Kurdistan Region Northern Iraq

By

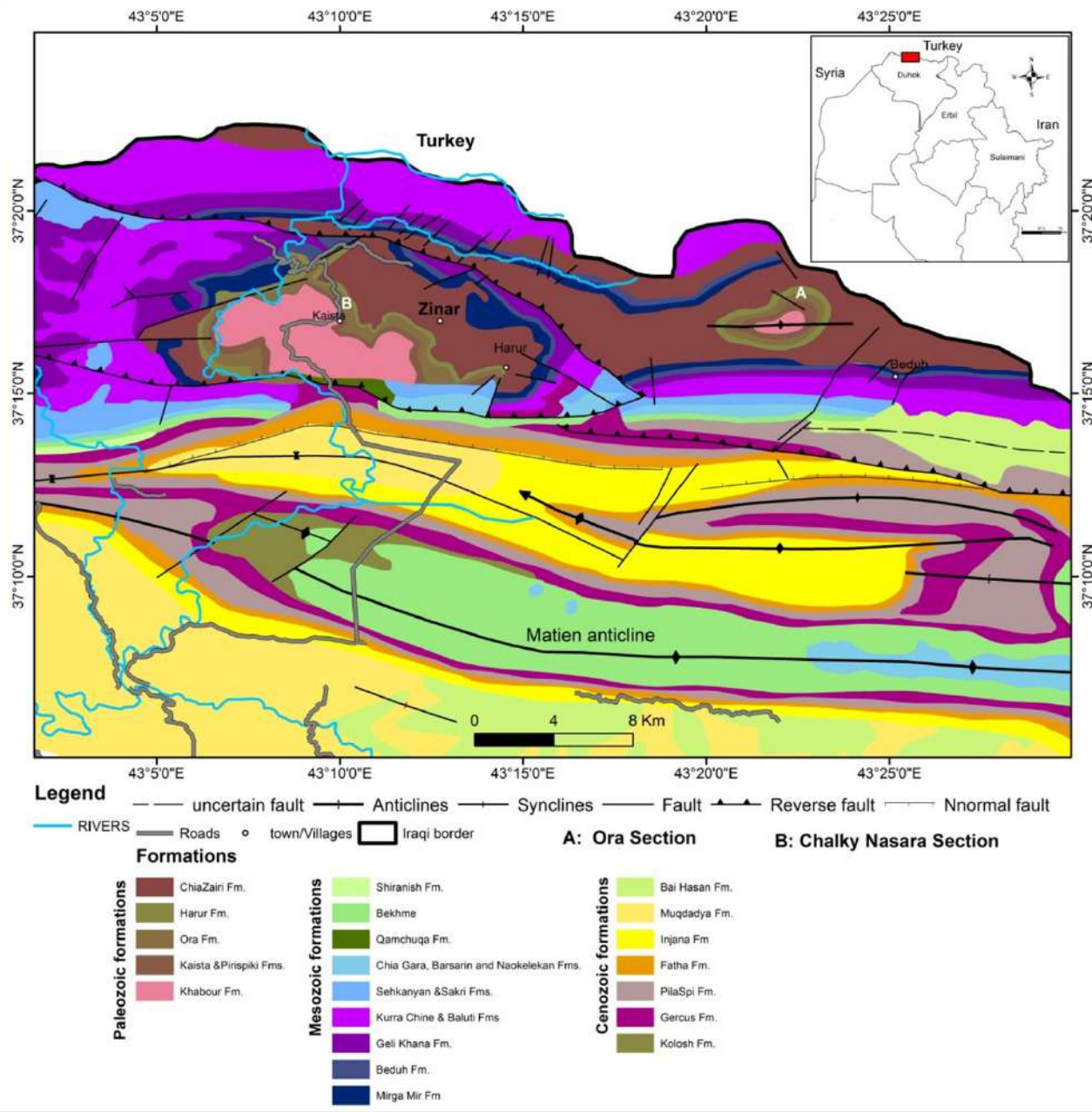
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A- Ora Section, in Ora Village, situated around to 42Km to the North-East of Zakho District, on the Longitude $43^{\circ} 21' 891''$ E, and Latitude $37^{\circ} 16' 579''$ N.

B- Chalky Nasara Section, near Kaista village, is situated around 9Km and 35Km to the North East of Zakho District, on Longitude $43^{\circ} 09' 116''$ E, and Latitude $37^{\circ} 17' 343''$ N.

Figure 1: Location and geological map showing Ora Formation and other Paleozoic rocks (Modified after Sissakian, 2000).

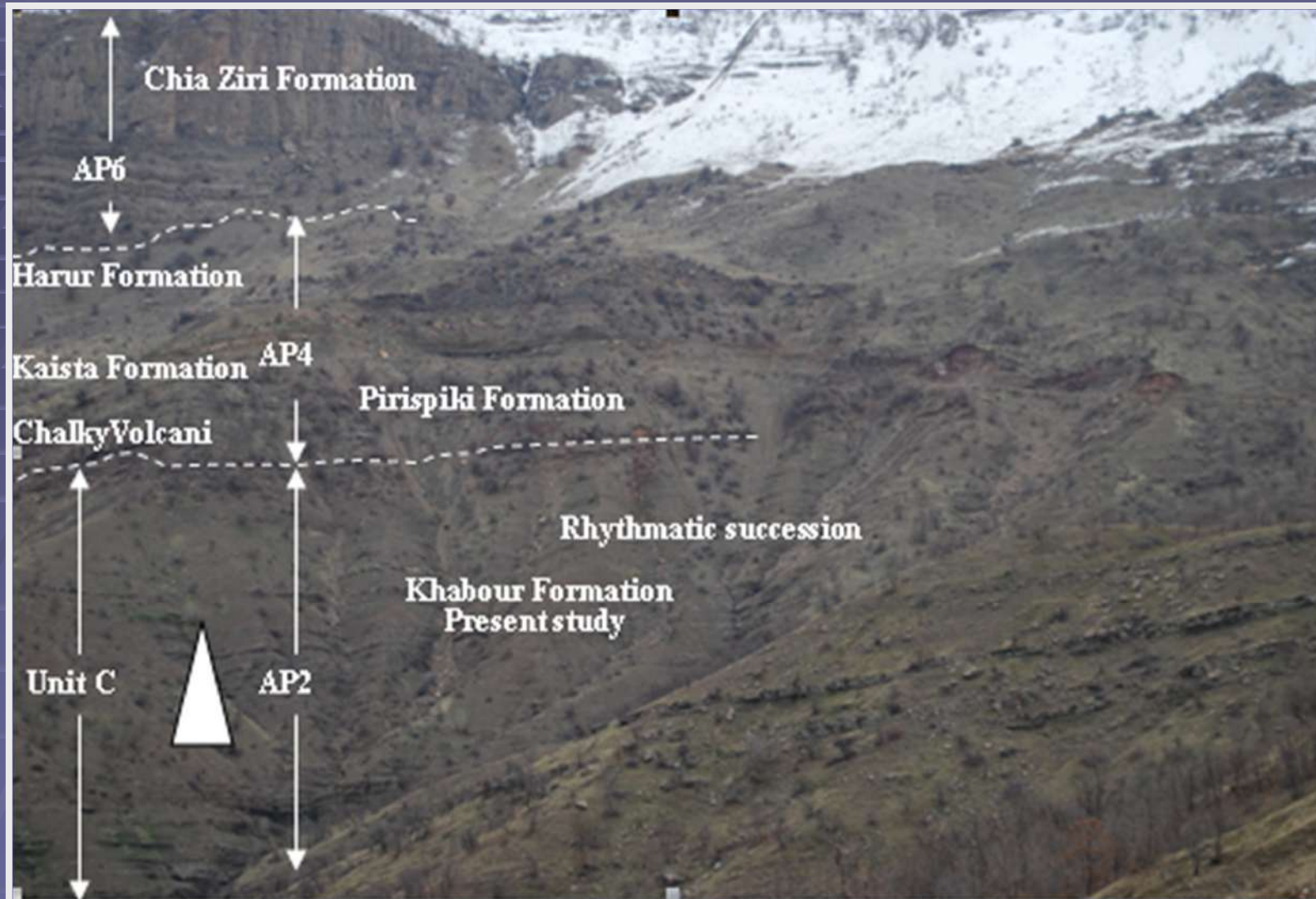


Figure 2: Schematic diagram showing Paleozoic Panorama successions and Megasequence of Northern Thrust Zone from Chalky Nasara Section.

----- Unconformity..



Aim and Main Objectives of Study

- 1-Performing facies analysis of the siliciclastic deposits from field depending, on lithology, kind of sedimentary structures, ichnofacies and grain size, then grouping them into Facies Association.
- 2-Determination depositional environment model of the formation according to facies analysis.
- 3-Evaluate the age of formation based on trace fossils.



Sandstone petrography

The sandstone of Khabour Formation is characterized by yellowish red to reddish brown color and they are relatively tough. In Chalky Nasara section a common hummocky cross stratification and other sedimentary structures were observed. Sandstone are makes a major constituents besides the shale and mudrocks, it representing about 64.67% of total thickness , and most of the thick sandstones are concentrated in lower part of the formation. The framework grains were counted by optical microscope for 400-500 counts per thin section.



Figure 3: Hummocky cross-stratification in fine grained sandstone present on Facies Association 8, from Chalky Nasara section.



A: Slump beds showing recumbent folds, slide surfaces and direction of movement (arrow), found in facies 23 Chalky Nasara section.



B: Herringbone structure where two opposite dipping less than 30° cross-bedded dash line, found in facies 19, from Chalky Nasara section.



Cruziana Rugosa ichnotaxa (Arenig-Llanvirn) stage. from Ora section.














Common of *cruziana goldfussi* ichnospecies (arrow) F12.



Cruziana Furcifera ichnotaxa with Khabour sediment found in Unit A Chalky Nasara section.

Table 1 Unit and Facies Classification Scheme for Khabour Formation

Unit and thickness	Facies Associations	Facies		
C 398m 223m *	 8	23-Siltstone interbedded micaceous shale. +		
		22-Thin laminated sandstone and silty shale. +		
		21-Thin well-bedded sand and silty shale. +		
 B 329m 22m *	 7	20-Phosphatic large-scale planner cross-bedded Sandstone. *		
		20-Black shale with thin intebedded phosphatic-Sandstone.		
	 6	19-Flaser and lenticular-bedded sandstone.		
		18-Channelled Sandstone.		
		 5	17-Upper hummocky cross-stratified sandstone.	
			16-Planner-bedded sandstone.	
			15-Thin-bedded sandstone.	
			14-Lower hummocky cross-stratified sandstone	
		A 79m	 4	13-Tabular cross-bedded sandstone.
				12-Very large scale cross-bedded sandstone (Cliniform).
11-Thick-bedded sandstone.				
10-Planner cross-bedded sandstone.				
 3	9-Dark grey shale.			
 2	8-Planner laminated sandstone.			
	2b  7-Massive quartzite sandstone.			
	2a  6-Ripple cross-laminated sandstone.			
	5-Convolute-bedded sandstone.			
 1	4-Unbioturbated gravelly sandstone.			
	3-Thin laminated mudstone.			
	2-Lenticular-bedded sandstone.			
	1-Wavy- bedded sandstone			

Note:- Without any significant represent Chalky Nasara section only.

+ Both sections.

* Ora section.

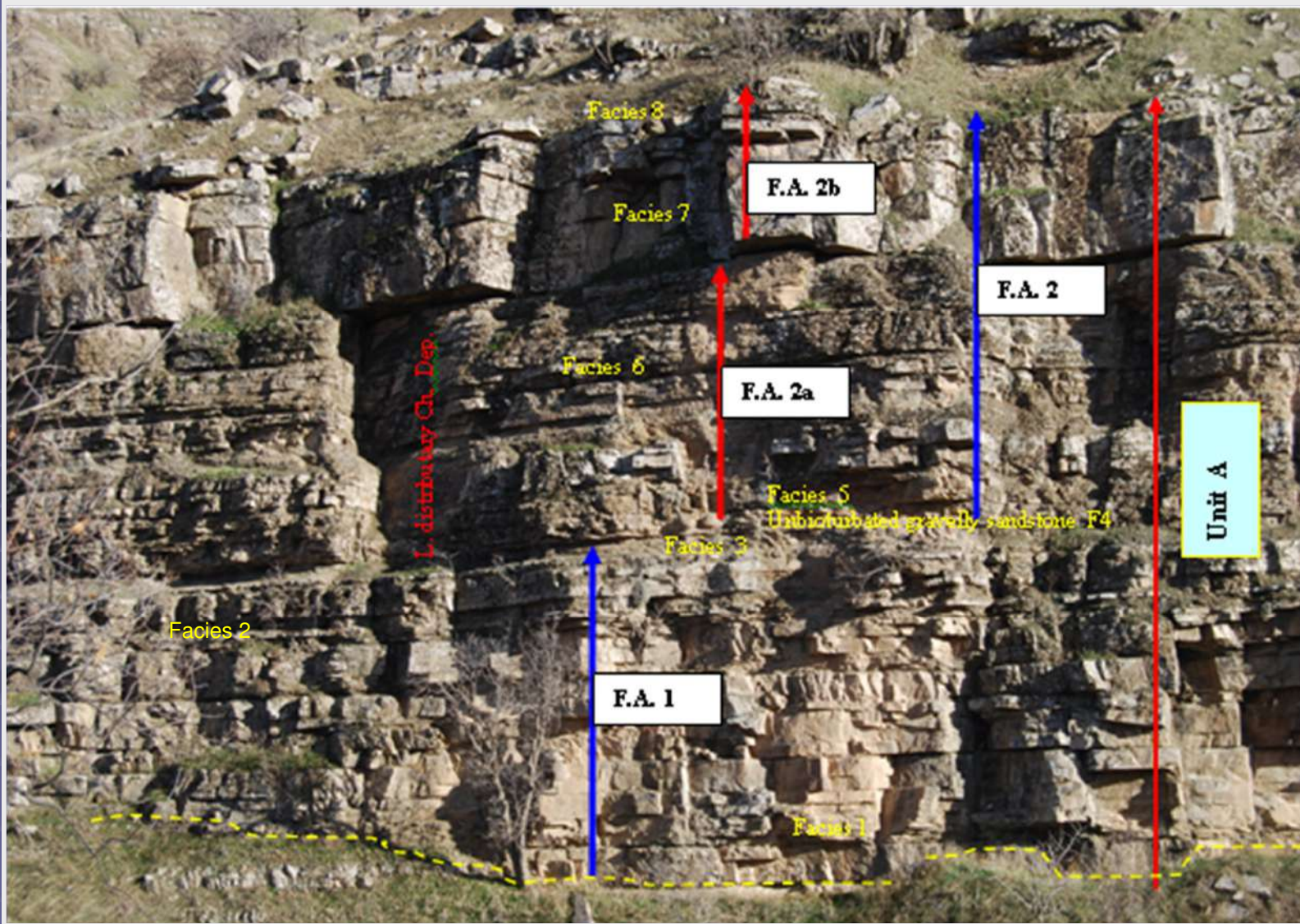


Figure 4: Panorama of the field showing lower part of Unit A, with two facies-associations FA1 and FA2 and thickening upward of Facies Associations 2. Dash line representing undulating contact with underlying black shale. Chalky Nasara section.

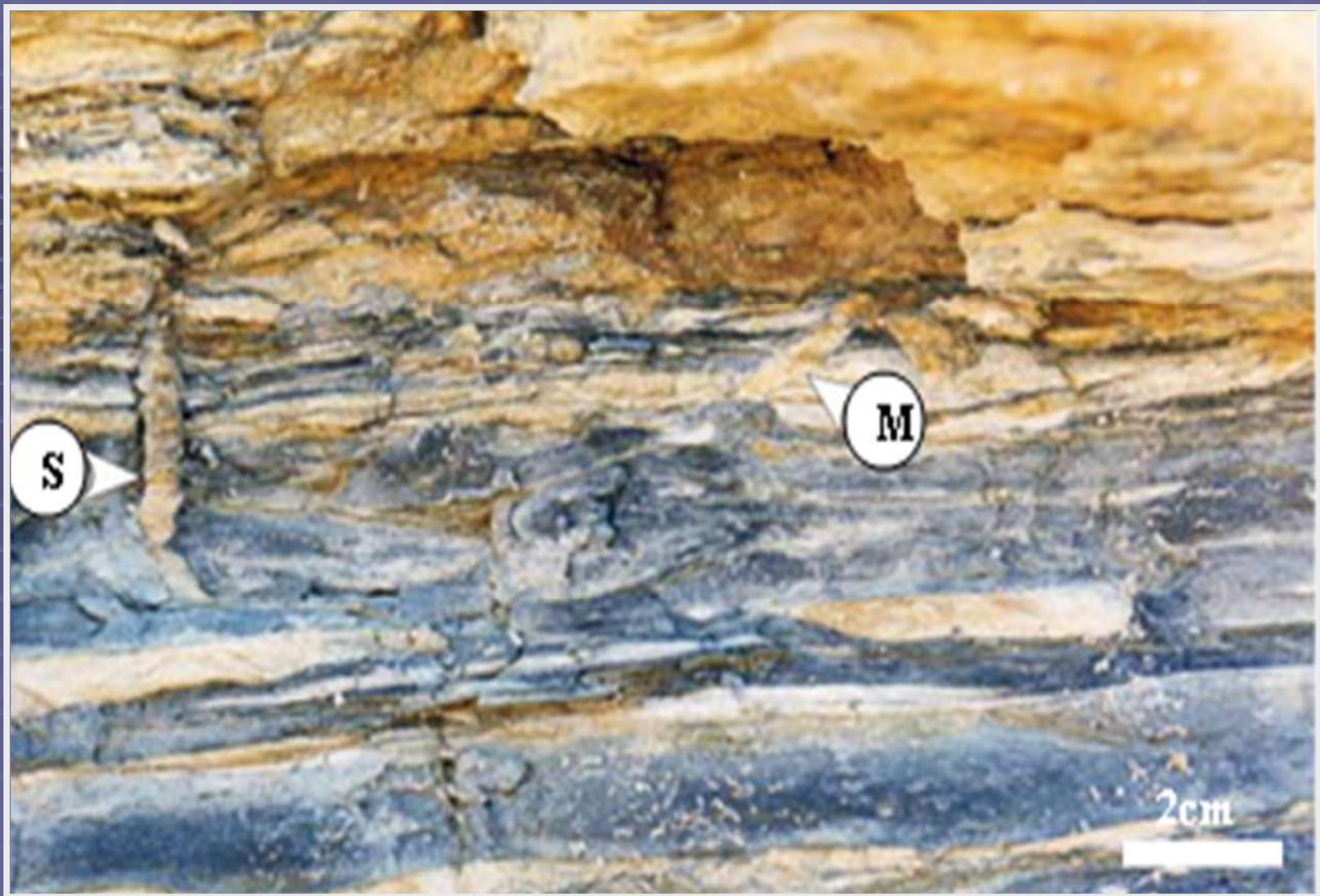


Figure 5: Photograph showing feeding burrows of skolithos (S) and (M) with Macaronichnus Isp. Chalky Nasara section

Back



Close up the same structure

Figure 6: Field outcrop showing convolute structure representing a turbidite sequence of zones C and undulating contact between F5 and F6. Chalky Nasara section.



Common of *cruziana goldfussi* ichnospecies (arrow) F12.

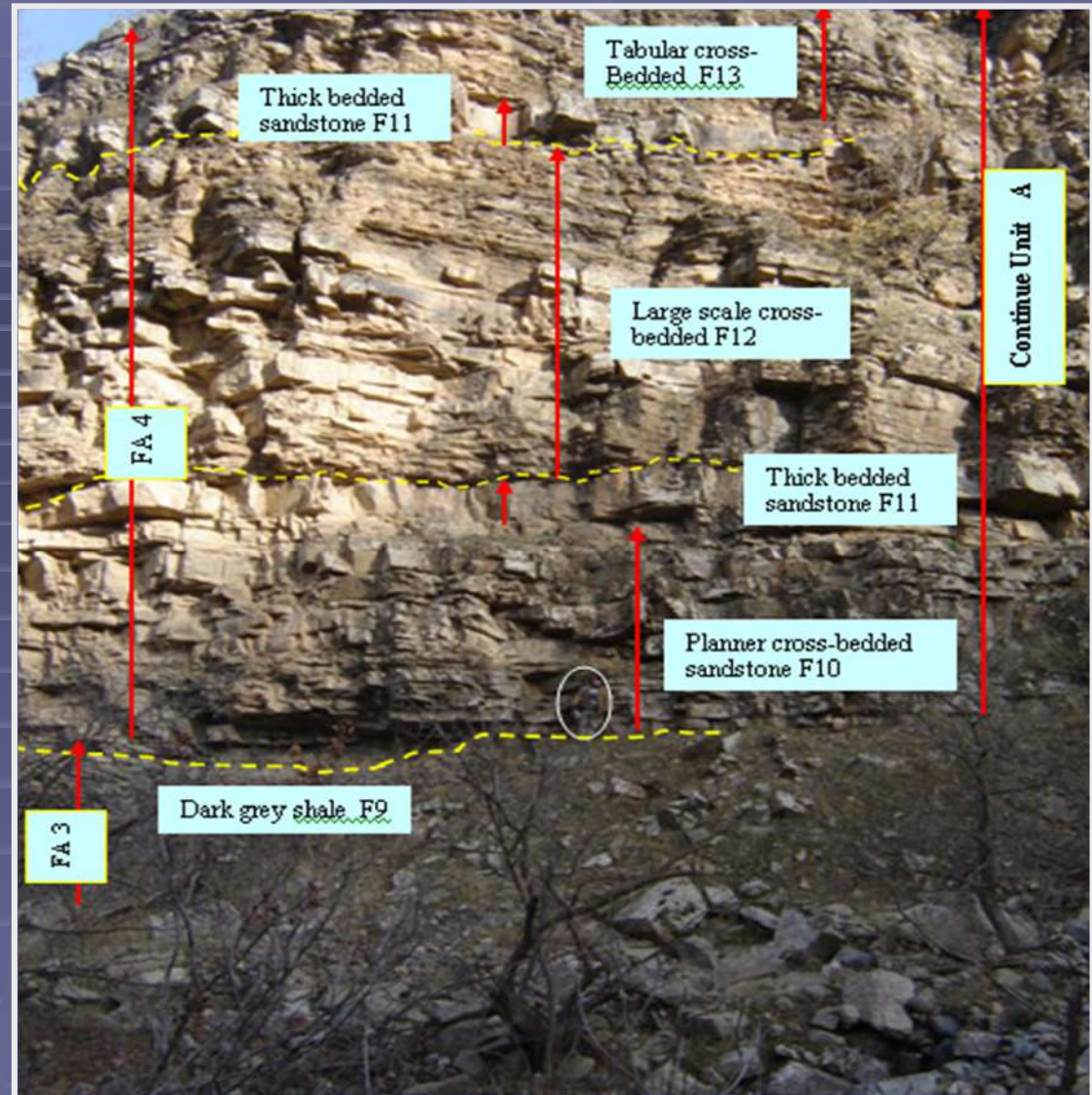


Figure 7: Panorama cross section showing Facies Association 4 and F12 represent of very large scale cross-bedded are embedded from base and top by thick bedded sandstone. View (F.A.4) is typical of delta-front deposits. An erosive surface (dash line). Chalky Nasara section

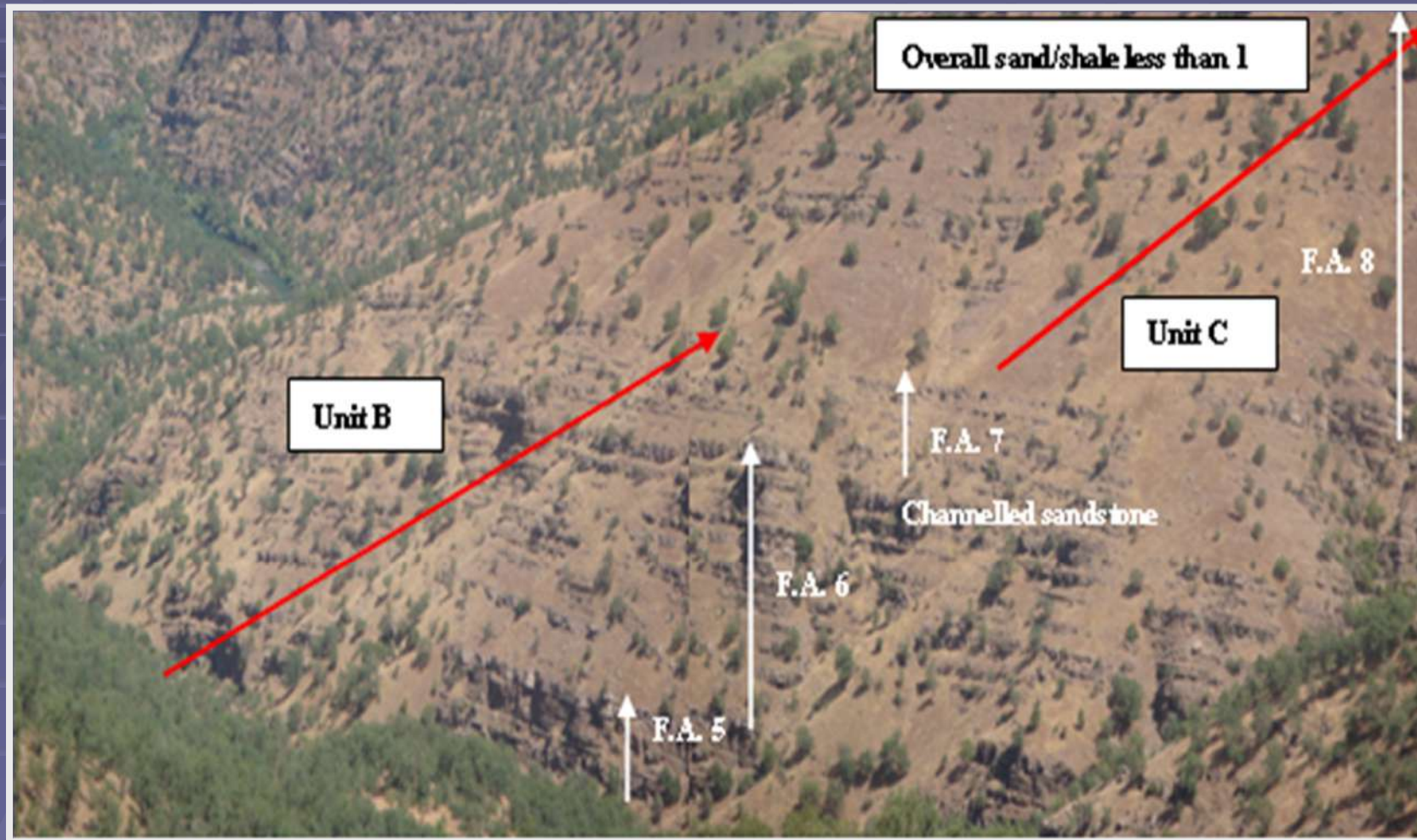


Figure 8: Panorama of the field view showing a subdivisions Facies Associations in Unit B, and fining thinning-upward of Unit C of Khabour Formation from Chalky Nasara section.

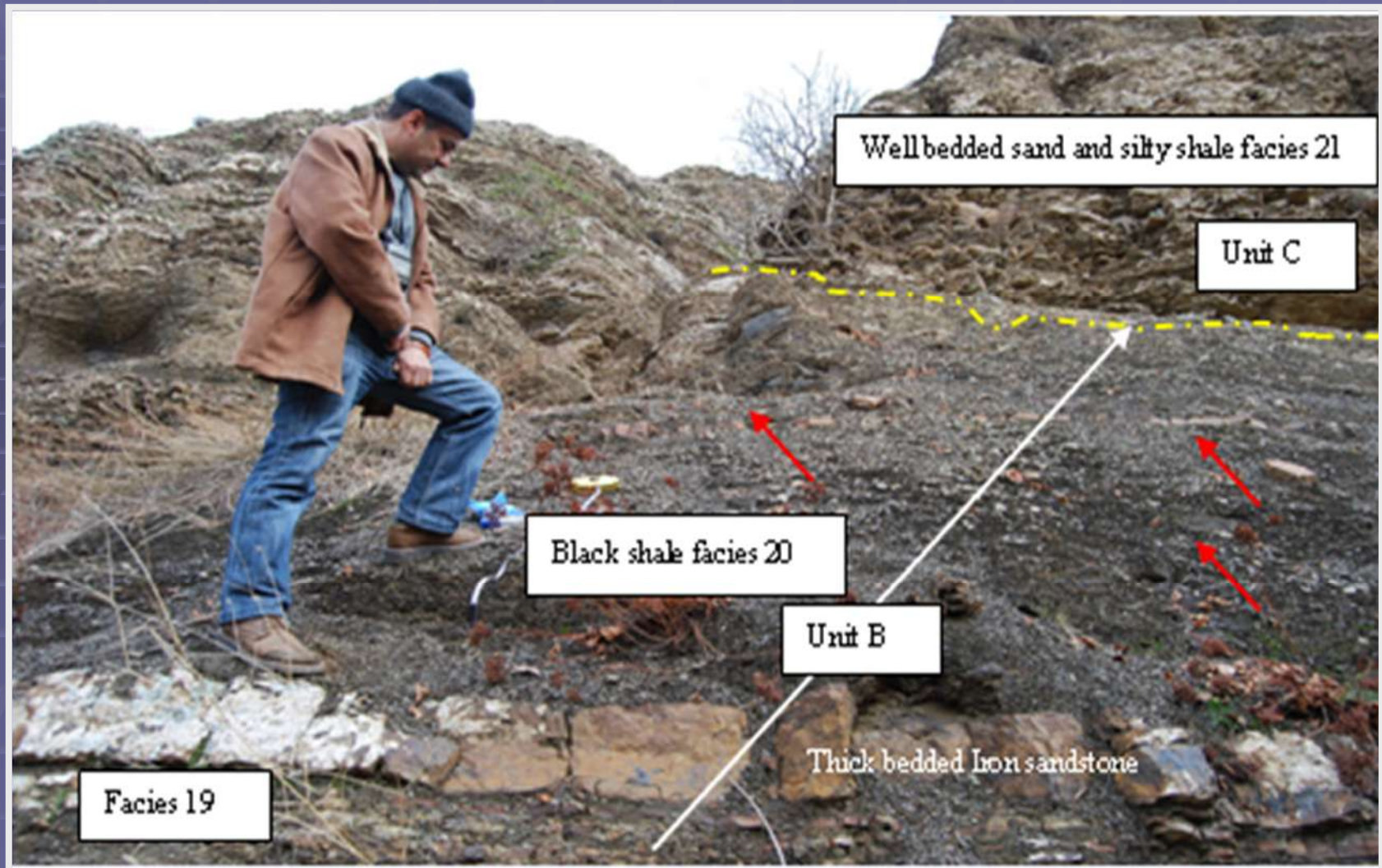


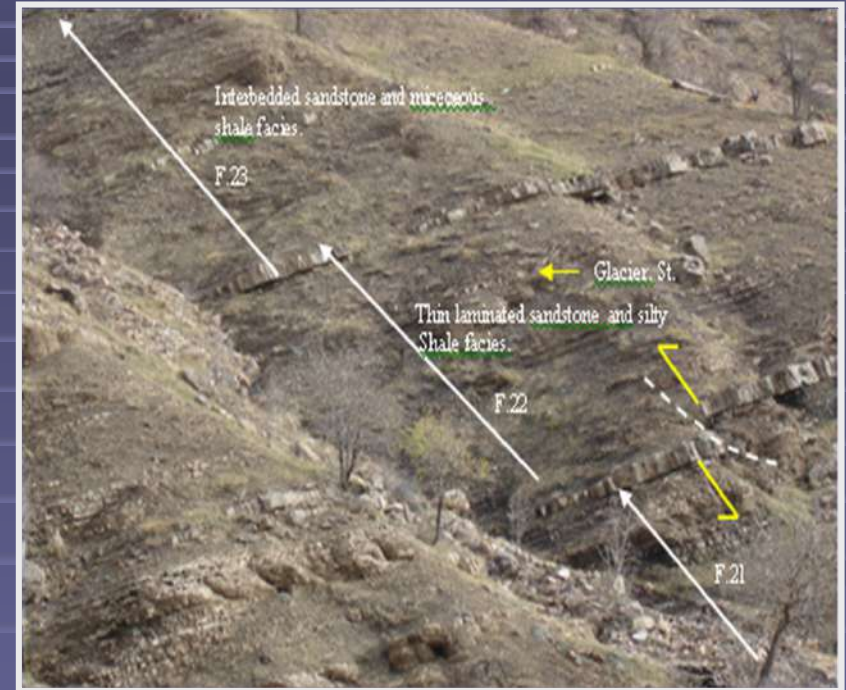
Figure 9: Field photograph showing black shale with interbedded phosphatic Sandstone facies. An erosional surface where separate two units B & C (dash line).Phosphatic sandstone (red arrow). Chalky Nasara section.



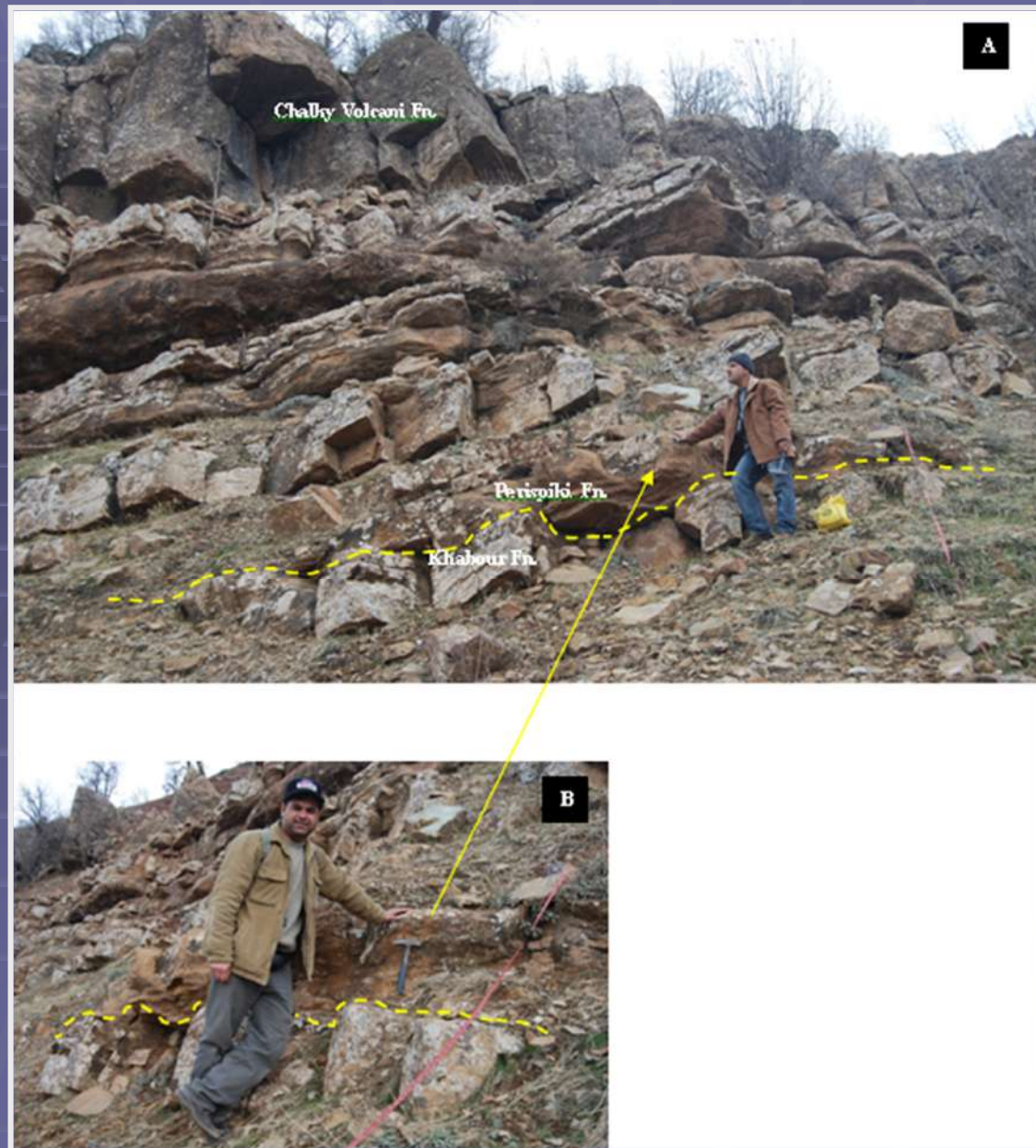
Outcrop field showing polished surface of glacier striations in thin-bedded sandstone

within F22(A).

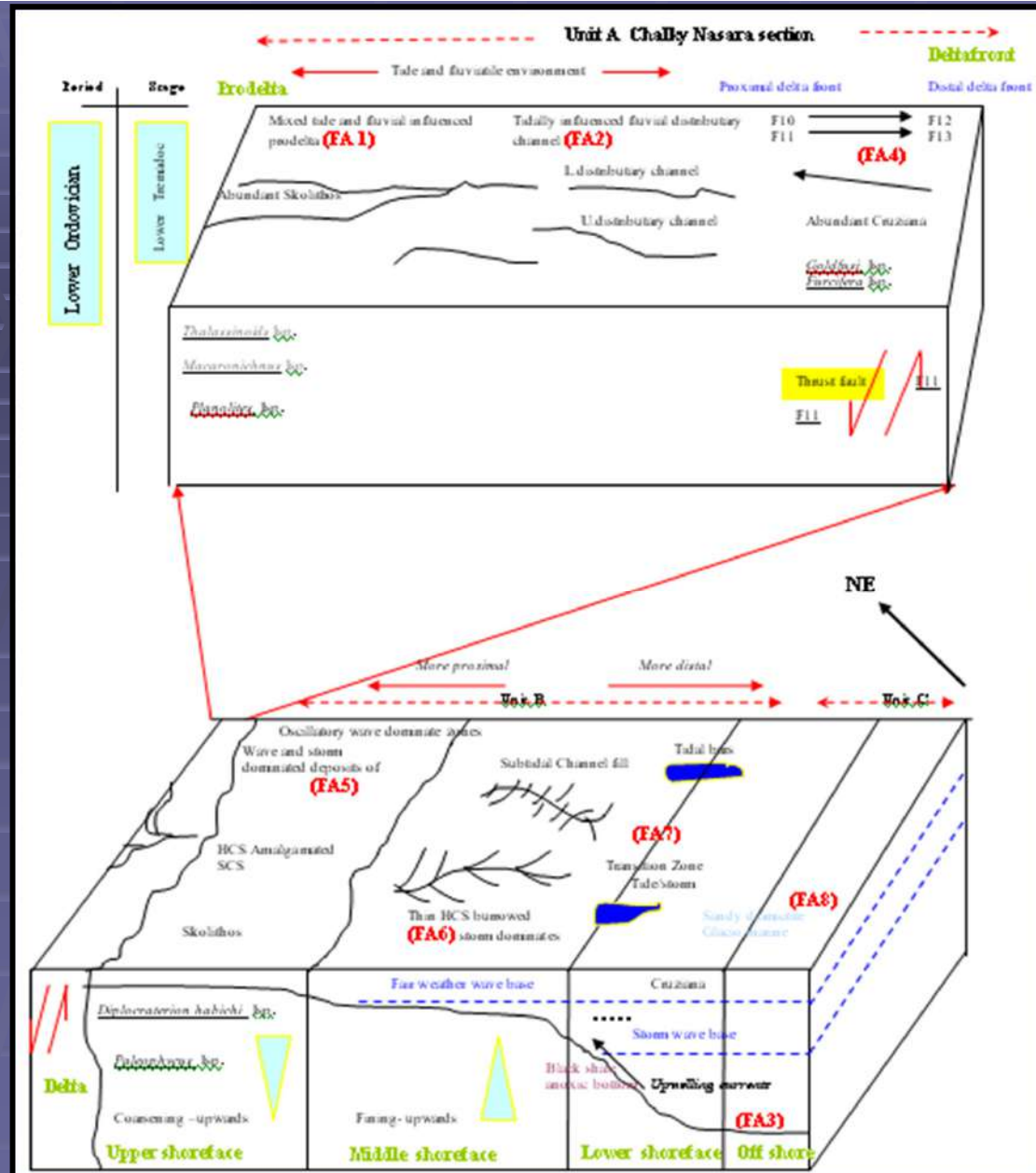
Chalky Nasara section



Outcrop field showing facies 22 and fining-upward in each facies. Thrust fault at a base of facies 22(reverse arrow) A glacier striations presence in upper of facies22.Chalky Nasara section.



Outcrop field showing a major unconformity (dash line) of undulated surface contact between Khabour and Perspiki Formation (A) .Close-up of a same view showing undulating surface contact (dash line) (B). Chalky Nasara section.



Block diagram showing the spatial relationships between the facies associations exposure outcrops from Khabour Formation Northern Iraq and their paleogeographical context.

Conclusions



- 1- According vertical lithological changes and boundaries between them Khabour Formation divided into three units A,B and C in Type locality Chalky Nasara section.
- 2- Eight Facies Associations recognized in Chalky Nasara and subdivided into twenty three subfacies.
- 3- Three ichnotaxa of cruziana *Fucifera*, *Goldfussi* and *Rugosa* reflects Lower Tremadocian Stages of Lower Ordovician age for the formation.
- 4-The turbidite packages are characterized generally by occurrence of incomplete Bouma in lower part of the formation Unit A. It deposited of pro-delta to delta-front environment.
- 5-The dominance of the subaqueous, storm generated channels in facies 18 of the Unit B in Chalky Nasara section, and the prevalence of HCS, indicate that storms dominated the shelf during deposition of the unit B.
- 6- Changing of sea level during (TST) coupled with upwelling currents created starved settings which is favorable for deposition of thin to medium-bedded of phosphatic sandstones associated with black shale.
- 7-Two types of phosphorite recognized in Khabour Formation , *Pristine phosphorite* in Chalky Nasara , and *reworked phosphorite* in Ora Section
- 8-A low diversity assemblages and individuals forms of skolithos ichnospecies *Palaeophycus Isp* and *Diplo craterion habichi Isp* were recognized in facies 16 among (FA5) corresponds to upper shoreface for Khabour Formation.

Thank you

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