

MICRO-PALEONTOLOGY AND LITHOSTRATIGRAPHICAL STUDY OF ILAM FORMATION IN LORESTAN PROVINCE OF IRAN (POSHTE JANGAL ANTICLINE)**ESTUDO MICRO-PALEONTOLÓGICO E LITO-ESTRATIGRÁFICO DA FORMAÇÃO DE ILAM NA PROVÍNCIA DE LORESTAN NO IRÃ (ANTICLINA POSHTE JANGAL)**Peiman Rajabi¹**ABSTRACT**

In order to undertake micropaleontological and petrological studies of Ilam formation in southwestern region of Khorramabad, a stratigraphy section on Poshte Jangal anticline has been selected. The real thickness of this section was 190 meters and mainly consisted of uniform alternations and a sequence of limestones aggregated on each other through a continuous sedimentation during mid-Turonian to pre-Campanian. The studies section showed that this formation has been laid down over Sourgah formation with a progressive boundary and covered by Gourpi formation as well with a progressive-continuous boundary. In present study, 10 types, 40 species, and two biozones of Foraminifera Planktonic have been discovered. In this study, two biozones have been observed and identified which represent the age of mid-Turonian to pre-Campanian for Ilam's formation in this stratigraphy section, based on its fossil distribution.

Keywords: Ilam formation; biozonation; Poshte Jangal anticline; Turonian; Campanian.

RESUMO

A fim de realizar estudos micropaleontológicos e petrológicos da formação de Ilam na região sudoeste de Khorramabad, o estudo apresentado selecionou uma seção de estratigrafia anticlinal de Poshte Jangal para a realização de sua descrição geológica. A espessura real desta seção possui 190 metros e consiste principalmente de alternâncias uniformes e uma sequência de rochas calcárias agregadas entre si por meio de uma sedimentação contínua ocorrida entre o meio da Turônia ao pré-Campaniano. A seção de estudos mostrou que essa formação foi estabelecida sobre a formação de Sourgah com um limite progressivo e coberta pela formação de Gourpi, bem como com um limite progressivo-contínuo. No presente estudo, 10 tipos, 40 espécies e duas biozonas de Foraminifera Planktonic foram descobertas. Neste estudo, duas biozonas foram observadas e identificadas que representam a idade do meio da Turônia ao pré-Campaniano para a formação de Ilam nesta seção de estratigrafia, com base em sua distribuição fóssil.

Palavras-Chave: Formação de Ilam; Biozonação; Anticlinal; Poshte Jangal; Turoniana; Campaniana.

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INTRODUCTION

The sedimentation of Ilam formation in high Cretaceous are located in a foreland basin with severe tectonic activities which we can refer to the subduction of Neotethys ocean crest under Iran's lithosphere during pre-post Cretaceous, subduction of ophiolite sheets from Neotethys ocean floor to the margins of Arabic continent in the higher Cretaceous and finally the clash between Afro-Arabic continental lithosphere with Iran's sheet during high Cretaceous and the following periods (Alavi, 2004).

In the folded Zagros, the upper part of the Cretaceous has been started from a sedimentation stop with low-depth limestones from Ilam formation and it continues with deep shales of Gourpi formation. Ilam formation is seen in two deep and shallow facies. Most of its facies in Lorestan are of deep ones and it possesses the features of an open-sea environment. The cross-section of this formation showing deep facies in north western terminal of Kabirkooch located in 12 km of Ilam town has been measured. In this section, Ilam formation includes 190 m of grey pelagic fine grain clay limestones with regular strata, and middle strata of thin shale belonging to Santonian-Campanian period.

Shallow facies of Ilam formation is expanded in regions of Fars and Khouzestan which includes rubble limestones, belonging to Santonian-Campanian period as well. In some regions, we can observe the inter-finger connection between two Pelagic and shallow facies of Ilam formation (Aghanabati, 2005). This formation belongs to Santonian period and it has a neritic facies in shallow regions of Dezfoul and Fars (Motiei, 1997).

LITERATURE REVIEW

Many researchers have been working on the carbonate sequence of the Ilam Formation. Asadi (2005) studied the geochemistry and lithology of Ilam Formation in Izeh region. In this study, by studying the oxygen and carbon isotopes of the paleoenvironmental reconstruction, this formation was identified in 4 tidal, lagoon, dam, and open sea facies belts.

Teymurian (2004) from the study of the Ilam Formation at wells 140 and 56 considered the Santonian age of this carbonate sequence. Chahardahcherik et al.(2006) provided a late Santonian-Campanian age range for biostratigraphic study of the Ilam Formation. Vaziri *et al.* (2006) in a south-western section of Khorramabad in a surface section suggested the age range of mid Santonian-Turonian based on Gradstein *et al.* (2004). Omrani (2009) in the stratigraphic section of Assaluyeh introduced the lower boundary of the Ilam Formation with disconformity on the Sarvak Formation and above as below the Gurpi Formation (Figure 1). Numerous other Researchers have done many studies on this formation which can be mentioned Shushtarian *et al.* (2011), Razazni *et al.* (2013), Bakhshandeh *et al.* (2014).



Figure 1. Structural map of the region under study.
Source: Berberian (1995).

GEOGRAPHICAL SITUATION AND ACCESS ROADS TO STRATIGRAPHY SECTION

The stratigraphy section under study is in southwestern Khorramabad (Zagros structural zone), within 70 km of the road between Khorramabad to Poldokhtar. The nearest village to the studies section is Chamheydar village, within a 5km distance. This section is in the margin of the road and one must pass the Lhorramabad-Poldokhtar road to gain access to it. The studies stratigraphy section's longitude are $47^{\circ}45'29''$ and $48^{\circ}56'58''$ E and latitude $33^{\circ}28' 19''$ and $33^{\circ}30'10''$ N (Figure 2).

METHOD

In order to study the stratigraphy's interval zone and sedimentation environment of Ilam Sazand in the section under study, 180 stone samples were taken from the limestones included in regular distances from each other in the separated section. In addition, in order to determine the upper and lower boundaries, 8 samples of the Sourgah Formation's shales and five samples from Gourpi formation's shales in the upper boundary have been extracted. The limestone samples have been cut into thin sections to be prepared for microscope study. The shale samples have been investigated using a two-eye microscope after being placed in oxygenated water and preparing them.

DESCRIPTION OF ILAM FORMATION'S STRATIGRAPHY IN THE SECTION UNDER STUDY

The successions of Ilam formation in the studies section and with a total thickness of 190 meter included an alternation of beige medium-sized to thick limestones. In addition, the few first meters of this formation included black thin shale layers. The lower boundary of Ilam formation consists of Sourgah foration's successions (Figure 3). This formation will gradually transform into Ilam formation and it includes an alternation of light grey tick limestones with mediating layers of green thin shales and marls. Studying its terminal 14 mm microphones shows that it belongs to middle-Turonian age (Figure 2).

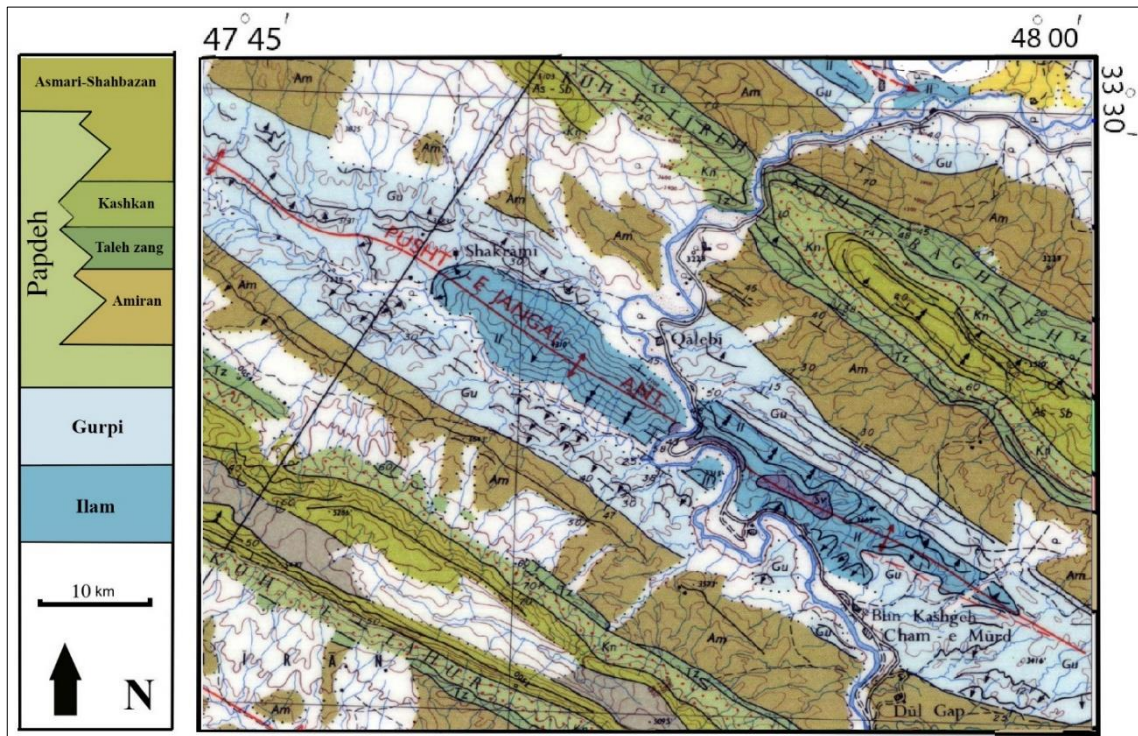


Figure 2. Geological map of the region under study, Poshte Jangal Anticline.
Source: National Iranian Oil Company, (1985).

The gradient and succession of Ilam's Pelagic limes in the studies section was an average of N259°W/53°SW. In the upper boundary, the thin limestones of shale layer from pre-Campanian belonging to Gourpi formation will appear gradually. The final 14 meters of Sourghah formation and first 12 meters of Gourpi formation have been sampled in order to determine lower and upper boundaries of Ilam formation.

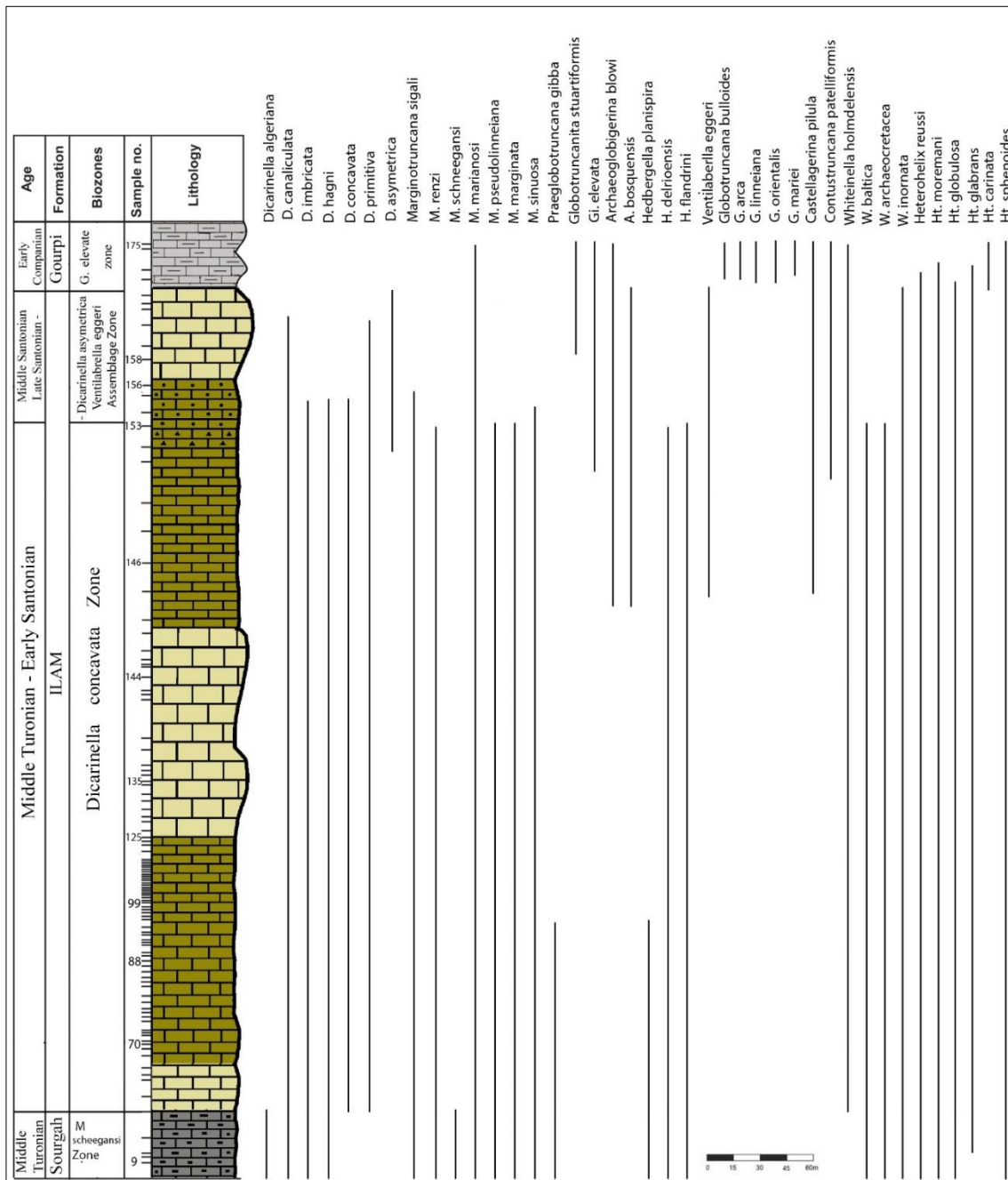


Figure 3. The stratigraphy's biozone column of the Ilam formation in the section under study. Source: Rajabi (2020).

THE STRATIGRAPHY OF SOURGAH FORMATION IN THE SECTION UNDER STUDY

In the final 14 meters of green shale and marls of Sourgah formation which consists of frequent iron nodules, different kind of floating Foraminifera Planktonic have been observed. They are:

- *Heterohelix reussi*, *Dicarinella concavata*, *Heterohelix globulosa*, *Dicarinella asymetrica*, *Archaeoglobigerina cretacea*, *Marginotruncana paraconcavata*, *Heterohelix moremani*, *Whiteinella baltica*, *Marginotruncana sinuosa*, *Dicarinella primitive*.

On the other hand, some bottom-living Foraminifera Planktonic such as the ones below have been observed:

- *Planularia dissona*, *Guaidryana pyramidata*, *Planularia tricarinnella*, *Frondicularia archiaciana*, *Lenticulina rotulata*, *Eouvigerina aculeate*, *Lagena lineata*, *Millioids*.

Accordingly, based on the fossil ingredients, one can argue that Sourgah formation in this stratigraphy section belongs to middle Turonian.

According to the observations made so far, and based on the pre-determined sedimentary cycles, Ilam formation in the studied stratigraphy section can be divided into three main sections in a bottom-up manner. They are:

- 8.4 meter: The first part includes an alternation of medium-sized beige limestones with mediating layers of thin gray shales. The existence of the investigated Foraminifera Planktonic in this section confirms that it belongs to middle Turonian-Coniacian;
- 9.6 meter: The second part under study consists of thick beige limestones with mediating layers of thin gray limestones. The foraminifera planktonic existing in this part determines that it belongs to middle-Turonian-Coniacian period;
- 172 meter: The third part consists of an alternation of medium sized to big beige limestones. The Foraminifera planktonic in this part are really similar to the other two previous parts. Though, the central parts are occupied by *Dicarinella asymetrica* belonging to Santonian period for a majority of third part and emergence of *Globotruncanita elevata* species in the final 2 meters show that the upper boundary of Ilam formation belongs to pre-Campanian period. Therefore, this section belongs to Santonian-pre-Campanian period.

THE STRATIGRAPHY OF GOURPI FORMATION IN THE SECTION UNDER STUDY

In the final 14 meters of green shale and marls of Sourgah formation which consists of frequent iron nodules, different kind of floating Foraminifera Planktonic have been observed. They are:

- Heterohelix reussi, Dicarinella concavata, Heterohelix globulosa, Dicarinella asymetrica, Archaeoglobigerina cretacea, Marginotruncana paraconcavata, Heterohelix moremani, Whiteinella baltica, Marginotruncana sinuosa, Dicarinella primitive.

On the other hand, some bottom-living Foraminifera Planktonic such as the ones below have been observed:

- Planularia dissona, Guaidryana pyramidata, Planularia tricarinnella, Frondicularia archiaciana, Lenticulina rotulata, Eouvirgerina aculeate, Lagena lineata, Milliolids.

Accordingly, based on the fossil ingredients, one can argue that Sourgah formation in this stratigraphy section belongs to middle Turonian.

THE STRATIGRAPHY OF ILAM FORMATION IN THE SECTION UNDER STUDY

According to the observations made so far, and based on the pre-determined sedimentary cycles, Ilam formation in the studied stratigraphy section can be divided into three main sections in a bottom-up manner. They are:

- 8.4 meter: The first part includes an alternation of medium-sized beige limestones with mediating layers of thin gray shales. The existence of the investigated Foraminifera Planktonic in this section confirms that it belongs to middle Turonian-Coniacian;
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- 172 meter: The third part consists of an alternation of medium sized to big beige limestones. The Foraminifera planktonic in this part are really similar to the other two previous parts. Though, the central parts are occupied by Dicarinnella asymetrica belonging to Santonian period for a majority of third part and emergence of Globotruncanita elevata species in the

final 2 meters show that the upper boundary of Ilam formation belongs to pre-Campanian period. Therefore, this section belongs to Santonian-pre-Campanian period.

THE STRATIGRAPHY OF GOURPI FORMATION IN THE SECTION UNDER STUDY

As it has been discussed earlier in this paper, the sedimentary facies of Gourpi formation in this stratigraphy section, equal to 12 meter has been cut in order to determine the upper boundary for Ilam formation. The studies fossil fauna in shale limestones and Gourpi formation's clay stones includes floating Foraminifera Planktonic such as the ones below which represents the lower-Campanian age. The kind of contact between this formation and Ilam formation in this section are continuous and progressive.

Globotruncana elevate, *Globotruncana linneiana*, *Globotruncana orientalis*, *Gavelinella sp.*, *Frondicularia sp.*, *Globotruncana arca*, *Globotruncana lapparenti*, *Globotruncana ventricosa*.

THE INTERVAL ZONES OF ILAM FORMATION IN THE STUDIED SECTION

From all the 180 samples taken from Ilam formation in this study, 10 types, 40 species and two biozones of floating Foraminifera Planktonic have been identified. The kinds of Foraminifera Planktonic present in this stratigraphy section are:

Marginotruncana sigali (Reichel), *Marginotruncana renzi* (Gandolfi); *Dicarinella canaliculata* (Reuss); *Dicarinella concavata* (Brotzen); *Dicarinella imbricata* (Mornod), *Dicarinella hagni* (Scheibnerova); *Dicarinella primitiva* (Dalbiz), *Dicarinella algeriana* (Caron), *Heterohelix globulosa* (Ehrenberg), *Marginotruncana schneegansi* (Sigal), *Marginotruncana marginata* (Reuss); *Marginotruncana marianosi* (Douglas), *Marginotruncana sinuosa* Porthault; *Marginotruncana pseudolinneiana* Pessagno, *Ventilabrella eggeri* Cushman; *Hedbergella delrionsis* (Carsey), *Heterohelix reussi* (Cushman); *Porthault*, *Hedbergella planspira* (Tappan); *Heterohelix moremani* (Cushman), *Whiteinella baltica* Douglas & Ranki, *lobotruncanita sturtiformis* (Dalbiez), *Archeoglobigerina bosquensis* Pessagno, *Whiteinella inornata* (Bolli); *Whiteinella archaeocretace* Pessagno, *Dicarinella asymerica* (Sigal);

Hedbergella holmelensis Olsson, *Globotruncana bulloides* Vogler, *Globotruncanita elevata* (Brotzen);

The above fossil aggregate led to identification of the emergence and extinction of prominent species of floating Foraminifera Planktonic in the studies section and finally resulted in the identification and introduction of the following interval zones.

DICARINELLA CONCAVATA ZONE

Dicarinella asymetrica - Ventilabrella eggeri Assemblage Zone

The emergence of *Dicarinella concavata* species after extinction of *Marginotruncana schneegansi* as well as the simultaneous emergence of two *Dicarinella asymetrica*, *Ventilabrella eggeri* species which continue living until the emergence of *Globotruncanita elevate* species resulted in the identification of the dual biozones mentioned above.

Besides all these points and considering the study of fossil aggregates in the studies section, it is suggested that Ilam formation in the section belongs to the middle Turonian-pre-Campanian (Gradstein et al. (2004). The starting point for Ilam formation's age in this section can be suggested to match that of Sourgah formation's succession which is defined by the extinction of *Marginotruncana schneegansi* species. In addition, in this study, the prominent species of *Helvetoglobotruncana Helvetica* has not been identified in Sourgah formation's successions which shows it belongs to pre-Turonian period (Vaziri *et al.*, 2009).

NO. 1 INTERVAL ZONE

Dicarinella concavata Zone

Age: Late turonian to earliest santonian

Author: Signal,1955.

This zone starts after the extinction of *Marginotruncana schneegansi* species or emergence of *Dicarinella concavata* in this stratigraphy layer and it continues living until the emergence of species such as *Dicarinella asymetrica*, *Ventilabrella eggeri*. In fact, the considered interval zone is located between *Marginotruncana schneegansi* interval zone

located in the bottom and the aggregate *Dicarinella asymetrica- Ventilabrella eggeri* Assemblage Zone in the upper end. Considering the above mentioned arguments and considering the emergence of the first *Dicarinella concavata* (Brotzen) species at the beginning of Late Turonian and emergence of *Dicarinella asymetrica* as the prominent species belonging to pre-Santonian, we can argue that this section of Ilam formation with a thickness of 5 meter belongs to Late Turonian-Early Santonian. Other fossils existing in this :

Dicarinella concavata (Brotzen). *Dicarinella canaliculata* (Reuss), *Dicarinella hagni*, (Scheibnerova); *Dicarinella primitiva* (Dalbiz), *Marginotruncana coronata* (Bolli), *Marginotruncana renzi* (Gandolfi)., *Heterohelix* sp., *Muricohedbergella* sp. (Gandolfi)., *Heterohelix* sp., *Muricohedbergella* sp. The No.1 interval zone in this study can be considered as being equivalent to two of Caron (1983)'s interval zones. They include *Dicarinella primitiva* Zone and *Dicarinella concavata* Zone.

NO. 2 INTERVAL ZONE:

Dicarinella asymetrica - Ventilabrella eggeri Assemblage Zone

After the last emergence of *Dicarinella concavata* and first emergence of *Globotruncanita* elevate in No. 2 Assemblage interval zone is the one present in this stratigraphy section. Considering the presence of prominent species such as *Ventilabrella eggeri* and *Dicarinella asymetrica* in this assemblage interval zone, we can argue that this interval zone belongs to middle-Santonian to post-Santonian (Figure 3). Some of the fossils included in this interval zone are:

Dicarinella asymetrica (Sigal), *Ventilabrella eggeri* Cushman, *Globotruncanita sturtiformis* (Dalbiez); *Globotruncana bulloides* Vogler.

No. 2 interval zone in this study is equivalent to *Dicarinella asymetrica* Zone in Caron (1983)'s study. The table below (Figure 4) illustrates the statistical variation of the prominent species in the studies stratigraphy section.

Age	Wonders (1980)	Caron (1985)	Sliter (1989)	Robaszynski & Caron (1995)	Premoli Silva Verga & (2004)	This Study
M.y	Thethys	Thethys	Thethys	Thethys	Thethys	Lurestan
Companian 83.5M.a	<i>G.elevata</i>				<i>G.elevata</i>	<i>G.elevata</i>
Santonian 85.8M.a	<i>carinata</i>	<i>Dicarinella asymetrica</i>	<i>Dicarinella asymetrica</i>	<i>Dicarinella concavata</i>	<i>Dicarinella asymetrica</i>	<i>Dicarinella -asymetrica</i> <i>Ventilabrella eggeri</i> Ass Zone
	<i>Dicarinella concavata</i>	<i>Dicarinella concavata</i>	<i>Dicarinella concavata</i>			
Coniacian 89M.a	<i>Dicarinella primitiva</i>	<i>Dicarinella primitiva</i>	<i>Marginotruncana sigali</i>	<i>Marginotruncana schneegansi</i>	<i>Marginotruncana sigali</i> <i>Dicarinella primitiva</i>	<i>Dicarinella concavata</i>
	<i>M.sigali</i>	<i>M.sigali</i>				
Middle Thoronian	<i>helvetoglobo truncana helvetica</i>	<i>helvetoglobo truncana helvetica</i>	<i>Marginotruncana sigali</i>	<i>helvetoglobo truncana helvetica</i>	<i>H.helvetica</i>	<i>Dicarinella concavata</i> Zone

Figure 4. Matching the introduced interval zones for middle Turonian-Post Campanian. Source: Vaziri Moghaddam (2002), modified by Rajabi (2020).



Figure 5. Two pictures from limestone succession of Ilam formation and Sourgah Formation in the studies section (East-ward view). Source: Rajabi (2020).

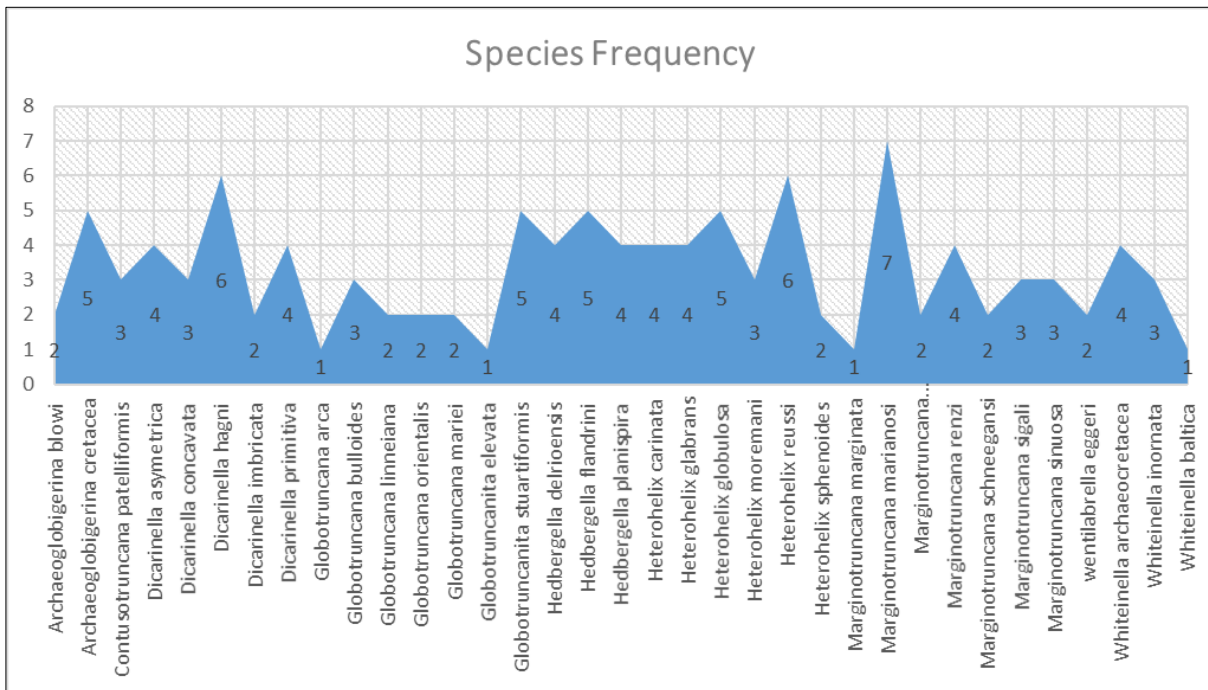


Figure 6. Statistical frequency of the identified species in this study.
Source: Rajabi (2020).

CONCLUSION

The lower boundary of Ilam formation in the studies section belongs to Sourgh formation. In fact, the terminal point of Sourgh formation matches the start of the *Dicarinella concavata* interval zone considering the termination of *Marginotruncana schneegansi* interval zone.

The upper boundary of Ilam formation in the section under study belongs to Gourpi formation which matches the starting point of *Globotruncanita elevata* interval zone.

According to the micropaleontological studies undertaken on a section taken from Ilam formation and observing and identifying 10 types, 40 species and two biozones (Figure 7), it has been arguing that this formation belongs to middle Turonian-pre Campanian

It has been argued in this study that *Marginotruncana schneegansi* species belong to middle Turonian and therefore it represents the age of llam formation. In addition, species such as *Heterohelix moremani* and *Marginotruncana marianosii* have been observed at the beginning of *Globotruncanita elevata* zone which are incompatible with Caron (1983) findings.

The extinction of *Marginotruncana schneegansi* is coincident with the emergence of *Dicarinella concavata*, therefore, its age will be increased up to the beginning of Coniacin period.

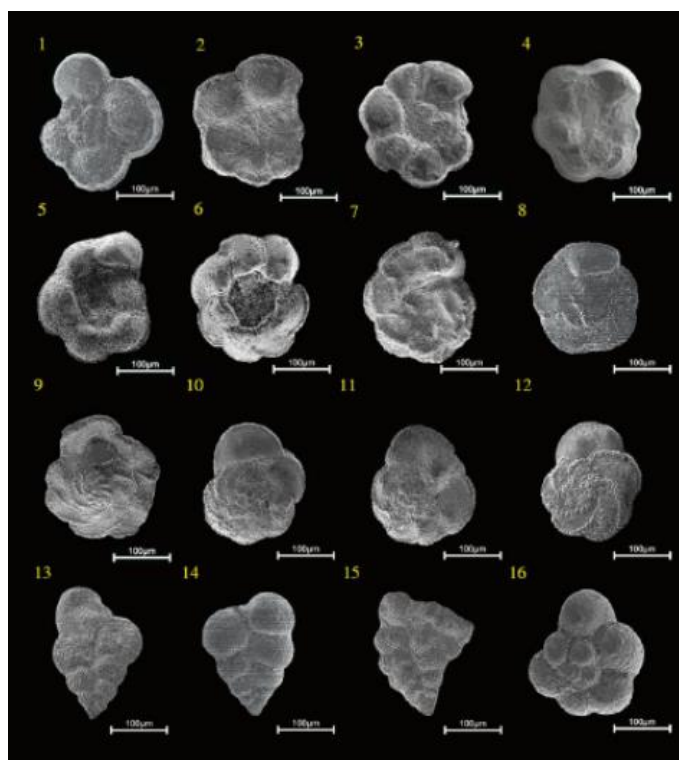


Figure 7. (1) *Dicarinella* sp; (2) *Dicarinella canaliculata*; (3) *Dicarinella imbricate*; (4) *Dicarinella concavata*; (5) *Dicarinella asymetrica*; (6) *Globotruncanita elevata*; (7) *Globotruncana arca*; (8) *Globotruncanita sturtiformis*; (9) *Globotruncanita elevata*; (10) *Marginotruncana marginata*; (11) *Marginotruncana* cf. *schneegansi*; (12) *Marginotruncana sigali*; (13) *Heterohelix reussi*; (14) *Heterohelix sphenoides*; (15) *Whiteinella archaeocretacea*; (16) *Ventilabrella eggeri*.

Source: Rajabi (2020).

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