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Revision of the foraminiferal biozonation scheme in Upper Cretaceous carbonates of the Dezful Embayment, Zagros, Iran: Integrated palaeontological, sedimentological and geochemical investigation

Révision des biozones de foraminifères du Crétacé supérieur du rentrant de Dezful, dans le Zagros : intégration des recherches paléontologiques, sédimentologiques et géochimiques

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Abstract

Cretaceous carbonate successions of the Bangestan Group, such as the Sarvak and Ilam formations, are among the most prolific hydrocarbon reserves of the Middle East. However, relatively little is known about their detailed palaeontology and biostratigraphy. Moreover, due to lithological similarity of these carbonate formations recognition of their boundaries in subsurface studies is problematic. To investigate these units, biostratigraphic analyses were carried out on nearly 1100 m of cores, including core plug samples and thin sections prepared from five giant and supergiant oilfields in the northern and southern Dezful Embayment, SW Iran. Accordingly, 59 species of foraminifera (assigned to 43 genera) as well as 11 species of non-foraminifera (10 genera) were recognized. As a result, three biozones were identified, which in stratigraphic order are: *Nezzazata*-Alveolinids Assemblage Zone; *Moncharmontia apenninica*-*Nezzazatinella*-*Dicyclina* Assemblage Zone; and *Rotalia skourensis*-algae Assemblage Zone. These are compared with the Wynd's (1965) biozonation scheme, previously introduced in the Zagros area, and a revised scheme is presented. Accordingly, a Cenomanian–Turonian age and a Coniacian–Campanian age are envisaged for the Upper Sarvak and Ilam formations, respectively. In our new biostratigraphic scheme, the Sarvak–Ilam formations boundary is considered to be located above the *Moncharmontia apenninica*-*Nezzazatinella*-*Dicyclina* Assemblage Zone (equivalent of *Valvulammina*-*Dicyclina* Assemblage Zone of Wynd, 1965), that is Turonian in age. This zone is bounded by two palaeoexposure surfaces, which correspond approximately to the C–T boundary transitional interval and a post-Turonian, which can be possibly assigned to the Coniacian. Significant sedimentological features of these unconformities include bauxitic–lateritic horizons, karstified profiles and solution-collapsed breccias. Geochemical signatures of these meteorically altered surfaces are also considered to calibrate biofacies and biozones. Finally, we compared our new biozonation scheme with other studies in neighboring areas of SW Iran and the Middle East.

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Keywords: Foraminifera; Biostratigraphy; Cretaceous; Stable isotopes; Palaeoexposure; Dezful Embayment; Iran

Résumé

Les séries carbonatées crétacées du Groupe de Bangestan, ou formations de Sarvak et d'Ilam, comptent parmi les plus riches réserves d'hydrocarbures du Moyen-Orient. Nos connaissances paléontologiques et biostratigraphiques restent cependant peu détaillées. En raison de lithologies similaires, les limites de ces formations sont difficiles à reconnaître en subsurface. Afin de pallier ce problème, des analyses biostratigraphiques ont été effectuées sur près de 1100 m de carottes, d'échantillons de modules de base et de lames minces, préparées à partir de trios

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champs géants et supergéants dans le nord et le sud du rentrant de Dezful (SW de l'Iran). Cinquante-neuf espèces de foraminifères (correspondant à 43 genres), ainsi que 10 genres et 11 espèces d'autres microfossiles ont été reconnus. En conséquence, trois biozones ont été identifiées, qui sont dans l'ordre stratigraphique : Zone d'assemblage à *Nezzazata*-Alveolinides ; Zone d'assemblage à *Moncharmontia apenninica*-*Nezzazatinella-Dicyclina* ; et Zone d'assemblage à *Rotalia skourensis*-algues. Ces résultats sont comparés avec la biozotation établie en 1965 par Wynd, dans les monts du Zagros. Un schéma révisé est présenté. Des âges cénomaniens–turonien et coniaciens–campaniens sont respectivement envisagés pour la partie supérieure des formations de Sarvak et d'Illam. Dans ce nouveau cadre biostratigraphique, la limite des formations de Sarvak et d'Illam semble pouvoir être fixée au-dessus de la zone d'assemblage à *Moncharmontia apenninica*-*Nezzazatinella-Dicyclina* (équivalent de la zone d'assemblage à *Valvulammina-Dicyclina* de Wynd, (1965)), dont l'âge est turonien. Cette zone est délimitée par deux surfaces d'émergence ; l'une se situant approximativement autour de l'intervalle transitoire de la limite Céno-manien–Turonien et l'autre étant post-turonienne, couvrant probablement le Coniacien. Ces discontinuités sont soulignées par des horizons bauxitiques et latéritique, des profils karstifiés et des brèches de dissolutions. Les signatures géochimiques de ces surfaces particulières sont également prises en compte pour recalibrer les biofaciès et les biozones. Enfin, nous avons comparé ce nouveau schéma de biozotation avec ceux des régions voisines du SW de l'Iran et du Moyen-Orient.

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Mots clés : Foraminifères ; Biostratigraphie ; Crétacé ; Isotopes stables ; Surfaces d'émergence ; Rentrant de Dezful ; Iran

1. Introduction

The aim of this study is to improve the biostratigraphic knowledge of the Cenomanian–Campanian carbonate successions (including the Sarvak and Illam formations, Bangestan Group) in the Dezful Embayment, southwestern part of Iran. After the Oligo-Miocene Asmari Formation, these two rock-units represent the second most important reservoirs of south and southwest Iran. In most parts of the Dezful Embayment, carbonate sequences of the Illam Formation disconformably overlie the carbonates of the Sarvak Formation. This lithological similarity causes some difficulties in their lithostratigraphic differentiation (especially in the subsurface studies). Together with sedimentological and geochemical investigations (Rahimpour-Bonab et al., 2012a, b, 2013; Mehrabi and Rahimpour-Bonab, 2014), biostratigraphy could provide a useful tool for relative dating and differentiation of these carbonate sequences (Zampetakis-Lekkas et al., 2007). Although the Bangestan carbonates are known as significant reservoirs in the Middle East, their detailed biostratigraphy is still ambiguous. As presented in Fig. 9, various biostratigraphic schemes are currently available for the Sarvak–Illam formations in the Zagros area; all are on the basis of Wynd's (1965) biozotation scheme. Since 1965, this scheme is widely used by researchers in both academic and industrial conventions. Due to the lack of any index and applicable planktonic fauna for biostratigraphic zonation, Wynd (1965) uses the small and large benthic foraminifera and other benthic fauna (e.g., algae) for his biozotation in the Sarvak–Illam formations.

One of the most important problems in the above mentioned studies is to define the boundary between the Sarvak and Illam reservoirs based upon their fossil content. Precise definition of the boundary is critical in both geological and reservoir aspects (e.g., reserves volume estimation).

In most parts of the Zagros area (including the Dezful Embayment), a regionally traceable disconformity separates the Sarvak and Illam formations. In many studies in Iran and other places in the Middle East, this disconformity is dated (both relatively and absolutely) in Middle to Late Turonian (Taghavi et al., 2006; Hollis, 2011; van Buchem et al., 2011).

In the Dezful Embayment, while many workers believe in only one unconformity in the Cenomanian–Campanian successions, they disagree on its stratigraphic position. Some (e.g. Wood and Lacassagne, 1965; Wynd, 1965) locate the boundary at the top of biozone 29 of Wynd (1965), while others (e.g. Bourgeois, 1969; Hart, 1970) favor a location at the base of this biozone. Recently, Ghabeishavi and Rahmani (2006), based on their biostratigraphic and sequence stratigraphic analyses of the Bangestan reservoirs, set the boundary somewhere within the biozone 29. However, Khalili (1976) assumes two major disconformities in the Sarvak–Illam sequences, bounding the biozone 29. Detailed characteristics of the Cenomanian–Campanian intervals are elaborated in this study in subsurface stratigraphic sections of the northern and southern Dezful Embayment. Finally, a revised biozotation scheme is presented for these lucrative successions in the Zagros area.

2. Geological setting and stratigraphy

The Cretaceous sedimentary record of the Middle East (including the Dezful Embayment of southwest Iran and Mesopotamian Basin of Iraq; Fig. 1) is one of the most important petroleum systems of the world (Alsharhan and Nairn, 1986). It mainly consists of shallow marine carbonates deposited on the ramp-like platforms, surrounding intrashelf basins in the north-eastern margin of the Arabian Plate (Setudehnia, 1978; Murris, 1980; Alsharhan and Nairn, 1986, 1988). In the Dezful Embayment, neritic carbonates of the Sarvak and Illam formations have developed on these shallow ramps from the Albian to Campanian (Motiei, 1993). As a result, benthic faunal assemblages are the best selections for biostratigraphic zonation of these sequences. On the other hand, in the Lurestan province, where the intrashelf basins have developed during the Cretaceous, pelagic fauna are more usable for biozotation (Bahramizadeh-Sajjadi, 2012).

Tectonically, the Middle Cretaceous marks an important period of change from a stable, passive margin, which had controlled sedimentation since the Permian, to an active margin with the initial phase of Neotethys closure and the onset of Alpine Orogeny (Sadooni and Aqrabi, 2000; Glennie, 2000; Ziegler,

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