Geologica Acta, Vol.15, N° 2, June 2017, 135-151
DOI: 10.1344/GeologicaActa2017.15.2.5

geologica acta

Foraminiferal-based paleobiogeographic reconstructions in the Carboniferous of Iran and its implications for the Neo-Tethys opening time: a synthesis

S. AREFIFARD

Geology Department, Faculty of Sciences, Lorestan University
Khorramabad, 68151-44316, Lorestan, Iran E-mail: sarefifard@gmail.com

ABSTRACT

The biogeographic distribution of foraminifers and their belonging to either the southern or northern margins of the Paleo-Tethys are used here for paleogeographic reconstructions of Iran during the Carboniferous. Lower Carboniferous foraminiferal assemblages from northern and central Iran show a cosmopolitan character and affinities to both the southern and northern borders of the Paleo-Tethys. Hence, in the Early Carboniferous Iran occupied an intermediate southern latitude position, forming part of Gondwana. This conclusion is consistent with the Late Ordovician to Early Carboniferous drift history of Iran based on paleomagnetic data. In the Late Carboniferous, the foraminiferal affinities of northern and central Iran with the northern part of Paleo-Tethys suggest that Iran separated from Gondwana and moved northwards to a lower latitude. This separation is also evidenced by the Upper Carboniferous coal-bearing sandstones of the Sardar Formation and sandstones with high degree of chemical weathering, which would indicate warm and humid conditions. Considering the composition of foraminiferal fauna along with the evidence of magmatic activities in northwest Iran, it can be inferred that the commencement of the Neo-Tethys opening and continental break-up in Iran occurred sometime in the Late Carboniferous, which contradicts the previous claims that the separation of Iran from Gondwana occurred in Permian and/or Triassic times.

KEYWORDS **Iran. Mississipian. Pennsylvanian. Foraminifera. Paleogeography. Neo-Tethys Opening.**

INTRODUCTION

Carboniferous deposits are sporadic and discontinuous in Iran except for Lower Carboniferous strata. The Alborz zone and central Iran have received most of the attention, being subject of stratigraphical and paleontological investigations (Bozorgnia, 1973; Vachard, 1996; Leven *et al.*, 2006; Leven and Gorgij, 2008; Falahatgar *et al.*, 2012, 2015; Zandkarimi *et al.*, 2014, 2017; Vachard and Arefifard, 2015). After the description of the Early Carboniferous Mobarak and Geirud formations by Assereto (1963, 1966), foraminiferal zonations were recognized in several stratigraphic sections of central and eastern Alborz Mountains (Bozorgnia, 1973; Lys *et al.*, 1978; Vachard, 1996; Ueno *et al.*, 1997; Brenckle *et al.*, 2009; Falahatgar *et al.*, 2012, 2015; Zandkarimi *et al.*, 2014, 2017). The Carboniferous deposits of central Iran have been studied in Tabas (Shotori, Shirgesht, and Ozbak-Kuh areas), Posht-e Badam and Yazd blocks and in the Shahreza area. Carboniferous foraminiferal associations of Central Iran have been reported from the Sardar Formation, at the North and South-East of the Tabas town, and from the Gachal Formation, Kalmard area, West of Tabas (Vachard, 1996; Leven *et al.*, 2006; Vachard and Arefifard, 2015). There are some other records of Carboniferous foraminifera in the Yazd Block (Leven *et al.*, 2006). In the Shahreza area only Upper Carboniferous foraminifers have been documented (Baghbani, 1993, Leven and Gorgij, 2008). In the Sabzevar zone, poorly preserved upper Pennsylvanian foraminifers have been reported (Gorgij and Leven, 2013).

The paleogeographical position of Iran during the Carboniferous has been discussed by many authors (Meissami *et al*., 1977; Sengör, 1990; Stampfli, 2000; Kalvoda, 2002; Torsvik and Cocks, 2004; Wendt *et al*., 2005; Devuyst, 2006; Brenckle *et al*., 2009; Muttoni *et al*., 2009; Zandkarimi *et al*., 2014, 2017; Vachard and Arefifard, 2015). In order to recognize the paleobiogeographic affinity of Iran during Carboniferous times, improved investigations of foraminiferal assemblages have been undertaken with the following results. In the Upper Paleozoic: i) foraminifers were widespread within tropical and subtropical paleolatitudinal belts (Boudagher-Fadel, 2008; Vachard *et al*., 2010; Davydov, 2014); ii) they were very sensitive to water temperature, and their associations display different compositions in lower latitude tropical-subtropical belts versus intermediate and higher latitudes, *i.e*. temperate and boreal belts (Beavington-Penney and Racey, 2004; Murray, 2006; Davydov, 2013; Prothero, 2013); iii) foraminifers had a rapid evolution reaching a high taxonomic diversity and iv) they have adapted to abiotic factors such as the paleoenvironmental shift led by tectonics (Kalvoda, 2002). The data for this study comprise author's own published and unpublished data gathered during years of field work in different parts of Iran and data from literature. Attention is first focused on the distribution of Carboniferous foraminifers in Iran to analyse later their affinity to either warm-water paleoequatorial belts, temperate belts, or cold-water higher latitude belts. Furthermore, the time of the opening of Neo-Tethys in Iran is discussed based on the integration of paleontological data with published data on Carboniferous volcanism and tectonics (Saccani *et al*., 2013; Tavakoli-Shirazi *et al*., 2013; Dilek *et al*., 2014; Moghadam *et al*., 2014).

GEOLOGICAL SETTING

Iran is located in the center of the Alpine-Himalayan orogenic belt which starts in western Europe and passes through Turkey, Iran, Afghanistan into Tibet and probably Burma and Indonesia, where it links with the circum-Pacific orogenic belt (Stöcklin, 1974; Moores and Twiss, 1995; Prelevi *et al*., 2013). Iran is divided into several tectonic units according to different stratigraphic, structural, magmatic and metamorphic features (Stöcklin, 1968; Stampfli, 1978; Berberian and King, 1981; Alavi, 1991; Golonka, 2002; Scotese, 2004; Torsvik and Cocks, 2004). For the structural divisions of Iran (Fig. 1), the tectonic maps by Alavi (1991) and Angiolini *et al*. (2007) are used herein.

PALEOBIOGEOGRAPHY

Foraminiferal realms during Late Paleozoic

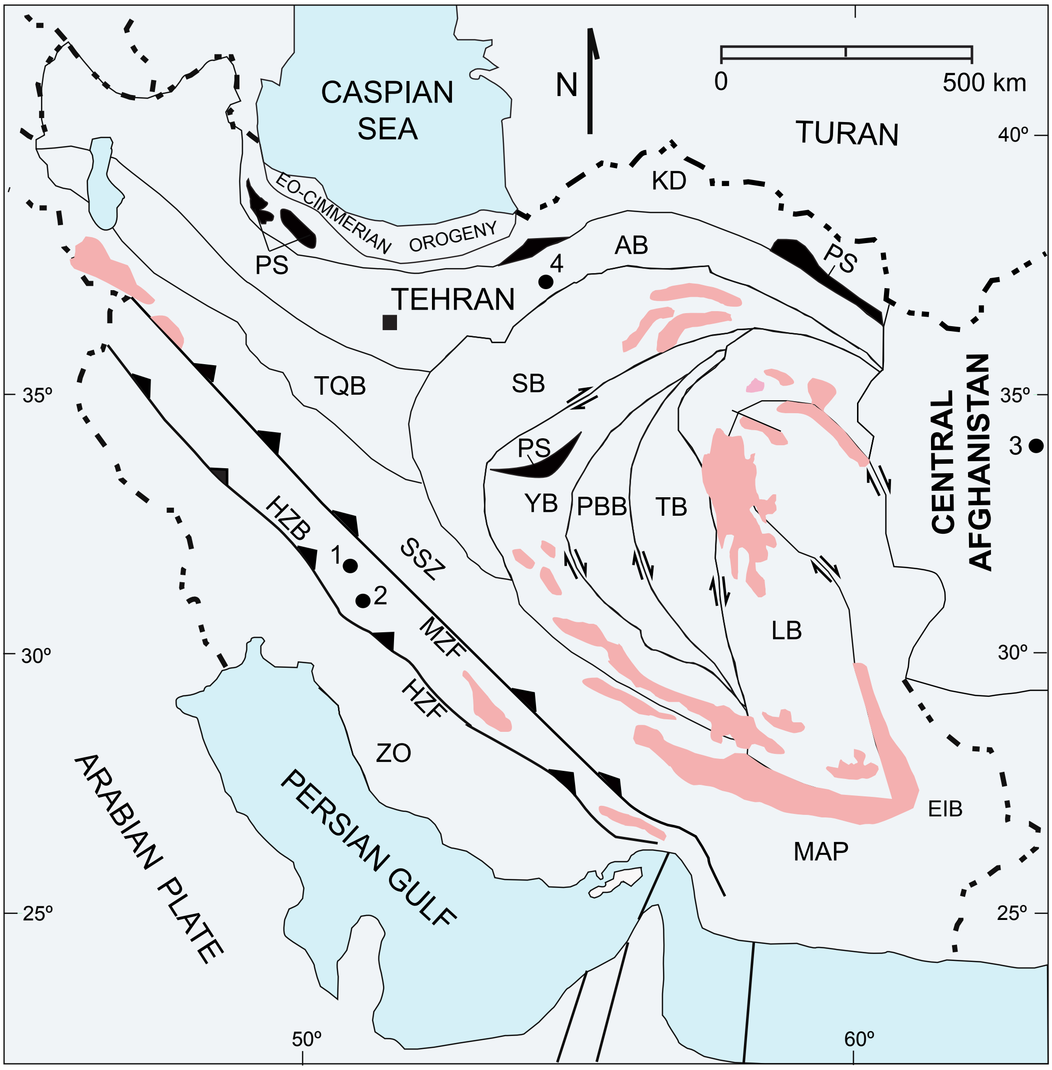
Traditionally, three major paleobiogeographic realms have been distinguished for the Upper Paleozoic foraminifers: i) tropical/subtropical Paleo-Tethyan realm, represented by highly diversified foraminiferal faunas, ii) the North American realm and iii) the northern Boreal or Uralian-Franklian realm (Lipina, 1973; Reitlinger, 1975; Ross and Ross, 1985; Kalvoda, 2002). In addition, two transitional realms have been reported to the North and South of the Paleo-Tethyan realm (Rui *et al*., 1991; Leven, 1993; Leven and Okay, 1996) that contain cold foraminiferal faunas which share common features. The southern transitional realm or peri-Gondwanan realm is reported from the Carboniferous to the mid Permian, latest Sakmarian and Artinskian up to the Guadalupian, (Leven, 1993; Kalvoda, 2002; Ueno, 2006; Davydov and Arefifard, 2007; Huang *et al*., 2015; Ueno *et al*., 2015). The northern transitional zone, known as the Arctic paleogeographic realm, subsisted from mid Pennsylvanian to early Sakmarian times. It included foraminifers with low diversity that developed from the northern Urals, in the East, to the Canadian Arctic and Alaska in the West (Rui *et al*., 1991).

Carboniferous foraminiferal assemblages in Iran

Alborz zone

In the Alborz zone, Carboniferous deposits are widespread in the central and eastern parts and are better documented than in other areas of Iran. Foraminiferal faunas are mostly attributed to the Mississippian (Tournaisian-Serpukhovian), with rare early and mid-Pennsylvanian (Bashkirian-Moscovian) records in eastern Alborz (Fig. 2).

Lower Tournaisian foraminifers have been reported only from a few sections, where the Upper Devonian and Lower Carboniferous deposits show stratigraphic continuity (Bozorgnia, 1973). These faunas include species-poor assemblages of earlandiid and septabrunsiid species belonging to biozones MFZ1 to MFZ5 (Bozorgnia, 1973; Vachard, 1996; Ueno *et al*., 1997; Brenckle *et al*., 2009; Falahatgar *et al*., 2015). There are conflicting ideas about the biogeographic affinity of these foraminifers. They have been both attributed to the southern Paleo-Tethyan domain (Meissami *et al*., 1977; Vachard, 1980; Wendt *et al*., 2005) and related to northern warm-water Paleo-Tethyan faunas (Kalvoda, 2002; Devuyst, 2006; Brenckle *et al*., 2009). The lower Tournaisian foraminiferal biozone contains *Earlandia minor* (Rauser Chernoussova, 1948) and *Septabrunsiina krainica* (Lipina, 1948) along with *Archaesphera magna* Suleimanov, 1945, *A.*



LB: Lut Block
TB: Tabas Block
PBB: Posht-e-Badam Block
YB: Yazd Block
SSZ: Sanandaj-Sirjan Zone
HZF: High Zagros Fault

SB: Sabzevar Block
EIB: East Iran Block
AB: Alborz Belt
MAP: Makran Accretionary Prism
MZF: Main Zagros Fault

TQB:Tabriz-Qom Block
ZO: Zagros Orogen
KD: Kopeh Dagh
PS: Paleo Tethys Suture
HZB: High Zagros

FIGURE 1. Generalized tectonic zonations of Iran (modified after Alavi, 1991; Angiolini *et al.*, 2007). Pink: Mesozoic ophiolites along Main Zagros Fault (MZF) and around central Iran. 1: Isfahan, 2: Shahreza, 3: Band-e Bayan, 4: Toyeh section.

minima SULEIMANOV, 1945, *Eotuberitina reitlingerae*, MIKLUKO-MAKLAY, 1958 and *Earlandia vulgaris* (RAUSER-CHERNOUSSOVA and REITLINGER in RAUSZER-CHERNOUSSOVA and FURSENKO, 1937) (Bozorgnia, 1973).

A recent investigation on the Tournaisian in the Kahanag section, central Alborz, revealed that the biozones MFZ1 to MFZ5 do not contain rich species assemblages in this region (Falahatgar *et al.*, 2015). In Alborz,The upper Tournaisian foraminiferal assemblages are more diverse than the lower Tournaisian ones. The MFZ6 to MFZ8 biozones (upper Tournaisian) include *Eotextularia diversa* (CHERNYSHEVA, 1948) (Bozorgnia, 1973) along with *Darjella monilis* MALAKHOVA, 1963 and *Eoforschia moelleri* (MALAKHOVA, 1953). Another upper Tournaisian foraminifer reported is *Eoparastaffellina rotunda* VDOVENKO, 1971 (Falahatgar *et al.*, 2015). The main representative species of the Tournaisian of western Europe, North America and the Russian Platform such as *Chernyshinella glomiformis* (LIPINA, 1948), *Chernyshinella multicamerata* (LIPINA, 1955), and *Brunsia* sp. MIKHAYLOV, 1935 (Kalvoda, 2002, 2003) are not found in this area. On the other hand,

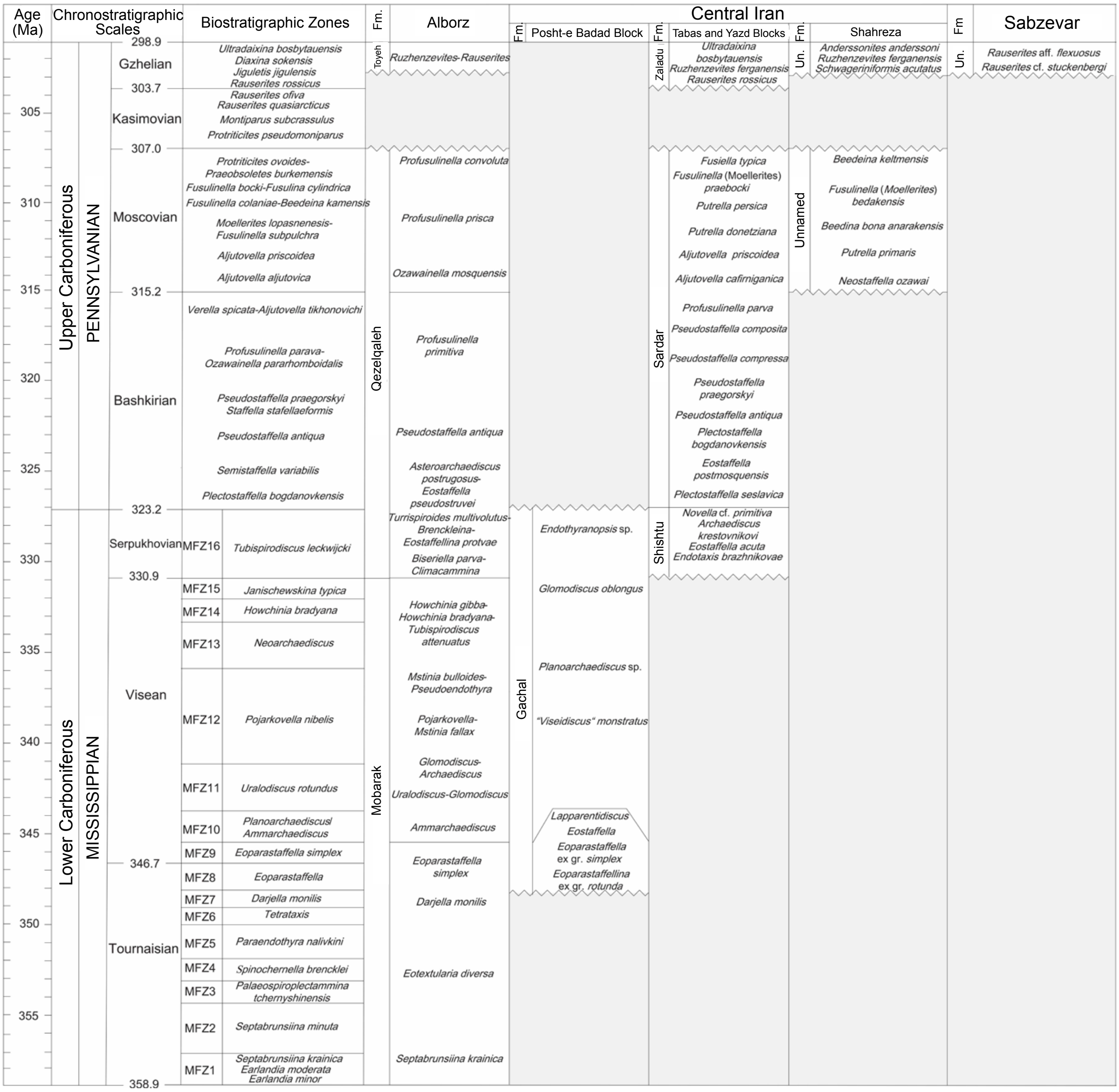


FIGURE 2. Correlation chart of the Carboniferous sections in Iran and their foraminiferal content. Alborz: Bozorgnia (1973); Lys *et al.* (1978); Vachard (1996); Gaetani *et al.* (2009); Zandkarimi *et al.* (2014, 2017); Falahatgar *et al.* (2015). Central Iran: (Tabas and Yazd blocks) Leven and Gorgij (2006a, b); Leven *et al.* (2011a, b); (Posht-e Badam Block) Vachard and Arefifard (2015). Shahreza: Leven and Gorgij (2008); Leven and Gorgij (2011c). Sabzevar: Gorgij and Leven (2013). Biostratigraphy adopted from Poty *et al.* (2006) and Davydov *et al.* (2014). Fm.: Formation, Un.: Unnamed.

the Alborz lower Tournaisian foraminifers have close similarity with their counterparts of South China, Turkey and Kazakhstan, which would indicate a peri-Gondwanan affinity (Arefifard, 1997; Falahatgar *et al.*, 2015).

Upper Tournaisian-upper Visean foraminiferal faunas have been reported in several studies (Bozorgnia, 1973; Vachard, 1996; Ueno *et al.*, 1997; Brenckle *et al.*, 2009; Zandkarimi *et al.*, 2014). Eight biozones were recognized, that are correlated with the biozones MFZ8-MFZ14 of Poty *et al.* (2006), which include the following species: *Eoparastaffellina* ex gr. *rotunda* Vdovenko, 1971-'*florigena*' Devuyst, 2006-*Lysella* cf. *gadukensis* Bozorgnia, 1973; *Eoparastaffella simplex* Vdovenko, 1971-*Lapparentidiscus bokanensis* Vachard, 1980; *Ammarchaediscus* Conil and Pirlet, in Pirlet and Conil, 1974; *Uralodiscus* Malakhova, 1973-*Glomodiscus* Malakhova, 1973; *Glomodiscus* Malakhova, 1973-*Archaediscus* Brady, 1873; *Pojarkovella* Simonova and Zub, 1975 emend. Cózar 2002 -*Mstinia fallax* (Rauser- Chernousova and Reitlinger in Rauser-Chernousova *et al.*, 1936); *Mstinia bulloides* (Mikhailov, 1939) emend. Dain, 1953-*Pseudoendothyra* Mikhaylov, 1939 and *Howchinia gibba* (Howchin, 1888)-*Howchinia bradyana* (Howchin, 1888)-*Tubispirodiscus attenuatus* (Marfenkova, 1978) (Zandkarimi *et al.*, 2014). The foraminiferal assemblages from biozones MFZ8 to MFZ11 reported from the Mobarak Formation in the Valiabad section, have been suggested to have a peri-Gondwanan affinity, whereas those of MZF12 to MZF14 are similar to the assemblages from the northern margin of Paleo-Tethys (Zandkarimi *et al.*, 2014).

The Serpukhovian in central and eastern Alborz is represented by two foraminiferal biozones, *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitch, 1936)-*Globivalvulina* sp. Schubert 1921 and *Eostaffella pseudostruvei* (Rauser-Cernoussova and Beljaev in Rauser-Chernousova *et al.*, 1936) -*E. mirifica* Brazhnikova in Brazhnikova and Rostovtseva, 1967 (Bozorgnia, 1973; Vachard, 1996) which indicate North Paleo-Tethyan elements (Kalvoda, 2002). Recently, Zandkarimi *et al.* (2017) reported two Serpukhovian biozones in northern Iran, the lower Serpukhovian *Biseriella parva* Chernysheva, 1948-*Climacammina* Brady, 1873, and the upper Serpukhovian *Turrispiroides multivolutus* (Reitlinger, 1949)-*Brenckleina* Zaninetti and Altiner, 1979-*Eostaffellina protvae* (Rauser-Chernousova, 1948). The Serpukhovian-Bashkirian in eastern Alborz comprises three foraminiferal biozones which are the *Asteroarchaediscus postrugosus* (Reitlinger, 1949)-*Eostaffella pseudostruvei* (Rauser-Cernoussova and Beljaev, 1936), *Pseudostaffella antiqua* Dutkevich, 1934 and *Profusulinella primitiva* Grozdilova and Lebedeva, 1954 (Lys *et al.*, 1978; Vachard, 1996). These biozones suggest southern Laurasian affinity (Kalvoda, 2002).

Gaetani *et al.* (2009) recognized the fusulinid species *Plectostaffella jakhensis* Reitlinger, 1971 indicative of early Bashkirian in the Dozdehband Formation in the Toyeh section from eastern Alborz. This fusulinid is also reported from Turkey, Russian Platform, Urals, Donets Basin and central Iran (Leven *et al.*, 2006).

Two Moscovian foraminiferal biozones were reported from eastern Alborz, the *Aljutovella tikhonovichi* Rauser-Chernousova in Rauser-Chernousova *et al.*, 1951 and Fusulinella ex gr. *bocki* Möeller, 1878 (Lys *et al.*, 1978; Vachard, 1996) indicative of the northern margin of Paleo-Tethys (Rui *et al.*, 1991, Kalvoda, 2002). Recently, Gaetani *et al.* (2009) reported fusulinids, *e.g.* *Ozawainella mosquensis* Rauser-Chernousova in Rauser-Chernousova *et al.*, 1951, *Pseudostaffella (P.) paracompressa* Safonova in Rauser-Chernousova *et al.*, 1951, *Taitzehoella* cf. *prolibrovichi* (Rauser-Chernousova, 1951), *Profusulinella prisca* (Deprat, 1912) and *P. convoluta* (Lee and Chen in Lee *et al.*, 1930), from eastern Alborz and referred them to the early Moscovian. These fusulinid faunas are also found in Eurasia, North America, South China, and Turkey and have Paleo-Tethyan affinities (Zhang *et al.*, 2003; Groves *et al.*, 2007; Okuyucu, 2009; Kobayashi, 2011). There is no evidence of Kasimovian deposits in this area.

One fusulinid assemblage *Ruzhenzevites* Davydov, 1986 -*Rauserites* Rosovskaya, 1950, from the latest Ghzelian, has been reported in the Toyeh Formation (Gaetani *et al.*, 2009). The fusulinids of this age were widespread in the warm water Paleo-Tethyan realm from the Carnic Alps, in the West, to South China, in the East (Leven and Taheri, 2003; Leven *et al.*, 2006).

Central Iran

Carboniferous foraminiferal faunas of central Iran are reported and described from the Tabas, Posht-e Badam and Yazd blocks and from the Shareza area (Baghbani, 1993; Leven and Taheri, 2003; Leven *et al.*, 2006; Leven and Gorgij, 2006a, b; Leven and Gorgij, 2008; Leven and Gorgij, 2011a, b, c; Vachard and Arefifard, 2015) (Fig. 2).

Lower Carboniferous foraminiferal assemblages have been described from the Gachal Formation in the Posht-e Badam Block. The rich associations of the uppermost Tournaisian-lower Visean foraminiferal biozones contain *Eoparastaffellina* ex gr. *rotunda* Vdovenko, 1971 (upper MFZ8), Eoparastaffella ex gr. simplex Vdovenko, 1971 (lower MFZ8-9), and *Eostaffella* Rauser-Chernousova, 1948 along with *Lapparentidiscus* Vachard, 1980 (upper MFZ9) (Vachard and Arefifard, 2015). They show a close resemblance with western Europe and southern Urals and have similarities with the coeval foraminiferal fauna from Alborz (Vachard and Arefifard, 2015).

The Visean-Serpukhovian foraminiferal fauna from the oolitic limestones at the topmost Gachal Formation, in the Padeh section, Posht-e Badam Block, have elements of northern Paleo-Tethyan affinity and contain *"Viseidiscus" monstratus* (Grozdilova and Lebedeva, 1954), *Planoarchaediscus* sp. Miklukho-Maklay in Kiparisova *et al.*, 1956, *Glomodiscus oblongus* (Conil and Lys, 1964), *Earlandia* sp. Plummer, 1930, *Eogloboendothyra?* sp. Vdovenko, 1972, *Pseudoplanoendothyra?* sp. Brazhnikova and Vdovenko in Brazhnikova, 1982 and *Endothyranopsis* sp. Cummings, 1955 (Leven and Gorgij, 2011a).

The foraminiferal fauna reported from the Zaladu section, Tabas Block, which is considered Serpukhovian in age, contains *Eostaffella acuta* Grozdilova and Lebedeva, 1950, *Archaediscus krestovnikovi* Rauser-Chernoussova, 1948, *A.* aff. *globosus* Conil and Lys, 1964, *Biseriella minima* (Reitlinger, 1950), *Endotaxis brazhnikovae* Bogush and Yuferev, 1966 and *Novella* cf. *primitiva* Rauser-Chernoussova, 1951 (Leven *et al*., 2006). It compares best with eastern European faunas (Rauser-Chernousova, 1948; Grozdilova and Lebedeva, 1950), Taurus faunas (Altiner and Özgül, 2001) and foraminifera from eastern Alborz (Lys *et al*., 1978; Vachard, 1996).

Foraminiferal assemblages representative of the Bashkirian-Moscovian interval are reported both from the Zaladu section, in Tabas Block, and the Anarak section, in Yazd Block. These relatively abundant associations of Bashkirian foraminifers include *Plectostaffella seslavica* (Rumyantseva, 1970), *P. bogdanovkensis* Reitlinger, 1980, *Eostaffella postmosquensis* Kireeva, 1951, *Semistaffella* sp. Reitlinger, 1971, P*seudostaffella antiqua* Dutkevich, 1934, *P. praegorskyi* Rauser-Chernoussova, 1938, *P. compressa* Rauser-Chernousova, 1938, *P. composita* Grozdilova and Lebedeva, 1950, *P. paracompressa* Safonova in Rauser-Chernousova *et al*., 1951 and *Profusulinella parva* (Leven *et al*., 2006).

A diversified association of Moscovian foraminifers in the Tabas and Yazd blocks contains *Aljutovella cafimiganica* Bensh, 1969, *A. priscoidea* (Rauser-Chernousova, 1948), *Putrella* sp. Rauser-Chernousova in Rauser-Chernousova *et al*., 1951, *P. donetziana* (Lee, 1936), *P. persica* Leven *et al*., 2006, *Fusulinella (Moellerites) praebocki* Rauser-Chernousova in Rauser-Chernousova *et al*., 1951 and *Fusiella typica* Lee and Chen in Lee *et al*., 1930 (Leven *et al*., 2006; Leven and Gorgij, 2011b). The Bashkirian-Moscovian foraminiferal associations in the Tabas and Yazd blocks represent typical elements of the eastern European Platform (Leven *et al*., 2006; Leven and Gorgij, 2011b).

There is no evidence of Kasimovian foraminiferal faunas in central Iran.

Baghbani (1993) reported on Moscovian foraminiferal associations from Tang-e Darchaleh section, near Shahreza town. They contain Endothyra spp. Phillips, 1846, Pseudostaffella sp. Thompson, 1942, Ozawainella mosquensis Rauser-Chernousova in Rauser-Chernousova *et al*., 1951 and representatives of the Fusulininae subfamily. These foraminifers are assigned to the Ozawainella mosquensis Rauser-Chernousova in Rauser-Chernousova *et al*., 1951 biozone with typical eastern European biogeographic affinities.

Moscovian fusulinids were also identified in the Asad-Abad section, NE of the Shahreza town and contain five typical assemblages of the northern Paleo-Tethyan domain (Middle Asia, Donbass, eastern European Platform), such as i) *Pseudostaffella gorskyi* (Dutkevich, 1934), *Neostaffella ozawai* (Lee and Chen in Lee *et al*., 1930), *Putrella* sp. Rauser-Chernousova in Rauser-Chernousova *et al*., 1951 ii) *Neostaffella umbilicata* (Putrja and Leontovich, 1948), *Putrella primaris* Leven, 2008 in Leven and Gorgij, 2008 iii) *Beedeina* ex gr. *samarica* Rauser-Chernousova and Belyaev in Rauser-Chernousova *et al*., 1940, *B. bona anarakensis* Leven and Davydov in Leven *et al*., 2006, *Citronites* aff. *apokensis* (Rauser-Chernousova in Rauser-Chernousova *et al*., 1951) iv) *Fusulinella (Moellerites) bedakensis* Solovieva, 1986, *F. (Fusulinella) pseudobocki* Lee and Chen in Lee *et al*., 1930, *F. (Fusulinella.)* aff. *fluxa* Lee and Chen in Lee *et al*., 1930, and v) *Beedeina keltmensis* (Rauser-Chernousova, 1953), *Kamaina* ex gr. *ozawai* (Rauser-Chernousova and Beljaev in Rauser-Chernousova *et al*., 1936) (Leven and Gorgij, 2008).

Data on the Gzhelian foraminiferal assemblages of central Iran were provided by Leven and Taheri (2003), Leven *et al*. (2006), Leven and Gorgij (2006a, b, 2011b). Their faunal lists contain mainly *Rauserites rossicus* (Schellwien, 1908), *Jigulites* cf. *formosus* Rosovskaya, 1950, *Ruzhenzevites ferganensis* (Dutkevitch, 1939), *Ultradaixina bosbytauensis* (Bensh, 1962) (from Anarak section, Yazd Block), *Rauserites samaricus* (Rauser-Chernousova, 1949), *Rauserites elongatissimus* (Rosovskaya, 1950) and *Ruzhenzevites ferganensis* (Dutkevich, 1939) (from Zaladu section, Tabas Block). These species were common along the northern margin of Paleo-Tethyan realm in Fergana (Bensh, 1972), Darvaz (Davydov, 1986), Carnic Alps (Forke, 1995, 2002, 2007), and Spain (Villa and Ueno, 2002). Typical northern peri-Tethyan elements have been reported from the Vazhnan Formation in the Asad-Abad section, North-East of the Shahreza town (Leven and Gorgij, 2011c). These faunas include *Schwageriniformis acutatus* Leven in Leven and Gorgij, 2006a, *Ruzhenzevites ferganensis* (Dutkevich, 1939), *R.* aff. *curtus* Leven in Leven and Taheri, 2003, *Rauserites baghbanii* Leven and Gorgij, 2011c, R. *karlensis* Rosovskaya, 1950, *R. ishimbaji* Rosovskaya, 1950, *Quasifusulina eleganta* Schlykova, 1948, *Anderssonites anderssoni* Schellwien, 1909 and *A.* aff. *zarjae* Potievskaya, 1964, *Schellwienia* ex gr. *stoecklini* Leven in Leven and Gorgij, 2006b.

Sabzevar zone

In this zone there is no evidence of the Mississippian, only the upper part of the Pennsylvanian is represented (Fig. 2). Gorgij and Leven (2013) found poorly determined fusulinid faunas, *Fusiella* (?) sp. Lee and Chen in Lee *et al.*, 1930, *Schubertella* sp. Staff and Wedekind, 1910, *Rauserites* cf. *stuckenbergi* Rauser-Chernousova, 1938, *R.* ex gr. *variabilis* Rosovskaya, 1950, *R.* aff. *karlensis* Rosovskaya, 1950, *R.* aff. *exilis* Rosovskaya, 1950, *R.* aff. *flexuosus* Rosovskaya, 1950, and *Rauserites?* sp. Rosovskaya, 1950, which were referred to the Gzhelian and are probably of Russian Platform affinity.

DISCUSSION

The paleogeographic reconstruction of Iran for the Late Paleozoic has always been controversial. The absence of Variscan orogeny in Iran and the resemblance of most Paleozoic deposits to their coeval strata in the Arabian Plate led to the idea that Iran had a Gondwanan affinity during the Late Paleozoic. The Late Paleozoic was a period of major tectonic events. By the Early Permian, the supercontinent Pangea had coalesced, the Paleo-Tethys ocean was closed, and Cimmerian terranes including present-day Turkey, Iran, Afghanistan, South Pamir, Karakoram, Tibet, Qiantang, Burma, Thailand and Malaysia broke-off from the northern margin of Gondwana and drifted northward across the Paleo-Tethys as a result of the Neo-Tethys opening to collide finally with the Eurasian margin in the Late Triassic, giving rise to the Eo-Cimmerian Orogen (Sengör, 1984; Scotese and Langford, 1995; Besse *et al.*, 1998; Metcalfe, 1999; Angiolini *et al.*, 2003; Kent and Muttoni, 2003; Ruban *et al.*, 2007; Muttoni *et al.*, 2009; Berra and Angiolini, 2014).

The taxonomic composition of Carboniferous foraminifers in Iran has been studied since the 1960s by Iranian and European workers. But, there is no consensus on their paleobiogeography. The results of previous studies suggest that these foraminifera were related to either the southern margin of the Paleo-Tethys (Meissami *et al.*, 1977; Vachard, 1980, 1996; Stampfli, 2000; Torsvik and Cocks, 2004; Brenckle *et al.*, 2009; Zandkarimi *et al.*, 2014; Qiao *et al.*, 2016) or the northern margin (Kalvoda, 2002; Devuyst, 2006). According to the paleomagnetic data from the Alborz zone, Iran shows an Apparent Polar Wandering (APW), well-matched with that of West Gondwana (Besse *et al.*, 1998; Muttoni *et al.*, 2009). These data suggest a paleolatitude for Alborz of about 40-45º South in the Early Carboniferous. Considering these data, North Iran was positioned in the northern margin of Gondwana during this period (Angiolini *et al.*, 2007; Brenckle *et al.*, 2009; Bahrammanesh *et al.*, 2011; Falahatgar *et al.*, 2015; Qiao *et al.*, 2016).

Paleontological evidence stands in opposition to the presumed 40-45º South location of North Iran in the Early Carboniferous. The smaller foraminifers and brachiopods reported from the Lower Carboniferous of Alborz are indicative of warm water (Brenckle *et al.*, 2009; Bahrammanesh *et al.*, 2011). Warm water faunas from Iran may be explained by a counterclockwise oceanic current that conducted equatorial warm Paleo-Tethyan waters to the peri-Gondwanan blocks, including Iran at the southern margin of the Paleo-Tethys (Kiessling *et al.*, 1999; Brenckle *et al.*, 2009; Bahrammanesh *et al.*, 2011). Additionally, during the Early Carboniferous there were no glacial events to hamper this warm surface current gyres and the dispersion of taxa from the tropics towards intermediate latitudes. Although the climate began to cool in the late Visean because of the onset of the late Visean glacial event (Melvin *et al.*, 2010), warm water and cosmopolitan faunas of this age in Alborz (Bozorgnia, 1973; Zandkarimi *et al.*, 2014) confirm the continuation of the warm surface-current gyres in the southern border of the Paleo-Tethys (Brenckle *et al.*, 2009).

Zandkarimi *et al.* (2014) and Falahatgar *et al.* (2015) speculated that Alborz was located in the southern margin of the Paleo-Tethys up to the early Visean, based on the presence of foraminifers with typical elements of peri-Gondwanan affinity. They hypothesized that since the Paleo-Tethys was narrow in the early Visean, the peri-Gondwanan terranes in the southern border of the Paleo-Tethys were easily connected with those of the northern margin. Moreover, these authors noted that the mid Visean foraminiferal assemblages in Alborz were similar to those of the northern margin of Paleo-Tethys and concluded that Alborz rifted from the northern margin of Gondwana and migrated to the North in the early mid Visean. They considered this as the first stage of the Cimmerian terranes assembly.

The upper Tournaisian-lower Visean foraminifers of Posht-e Badam, central Iran, are similar to those of Alborz (Vachard and Arefifard, 2015). It has also been mentioned that the foraminiferal species identified in the Lower Carboniferous of the Posht-e Badam Block have common features with both the northern and southern margins of the Paleo-Tethys. Vachard and Arefifard (2015) suggested that since Alborz has been attributed to the peri-Gondwanan margin during the late Tournaisian-early Visean by many authors, the Posht-e Badam Block was probably located in the southern margin of the Paleo-Tethys as well.

Bashkirian-Moscovian foraminiferal assemblages have been examined both in North and central Iran, but beyond these regions there are no reports in Iran, possibly due to the lack of deposition or erosion. In the Tang-e Darchaleh section, near the town of Shahreza, Moscovian foraminifers were reported and showed biogeographic affinity with the eastern European platform (Baghbani, 1993). The Bashkirian-Moscovian foraminiferal associations in

North and central Iran reveal great similarities. They also show strong relationship with coeval foraminifers from Turkey, central Asia, Donets, Russian Platform and the Urals located in the northern margin of the Paleo-Tethys during this period (Kalvoda, 2002; Leven *et al*., 2006; Dzhenchuravea and Okuyucu, 2007).

Vachard (1980, 1996) compared the Carboniferous deposits in the Tabas region, Central Iran, with those of central Afghanistan, and the ones in Alborz strata with the Band-e Bayan sequences in northern Afghanistan. He concluded that there were no similarities between the Carboniferous basins in North and central Iran. Leven *et al*. (2006) objected to Vachard's correlations and suggested that there is no faunal evidence to support these comparisons. They argued that Bashkirian-Asselian foraminifers in Iran are not endemic and both central and North Iran belonged to the same basin in the Bashkirian-Moscovian time.

There is no evidence of Kasimovian foraminifers in Iran, may be as a result of a regional regression and subsequent subaerial erosion. The uppermost Gzhelian foraminiferal faunas in Alborz, central Iran and the Sabzevar zone contain typical elements of the northern margin of the Paleo-Tethys and have resemblance to those of the Carnic Alps, Donets Basin, Eastern European Platform, Darvaz and Fergana (Leven and Gorgij, 2006a,b; Gaetani *et al*., 2009; Leven and Gorgij, 2011a,b,c; Gorgij and Leven, 2013).

Based on the available data on Lower Carboniferous foraminifera, it is plausible that Iran was located in the southern margin of the Paleo-Tethys and displayed a peri-Gondwanan faunal biogeographic affinity in the Early Carboniferous (Fig. 3). The presence of faunal elements of both northern and southern Paleo-Tethys supports this idea (Bagheri and Stampfli, 2008; Brenckle *et al*., 2009; Bahrammanesh *et al*., 2011; Berra and Angiolini, 2014; Vachard and Arefifard, 2015). Furthermore, the concurrent occurrences of both faunas may be explained, either by the southerly circulation of the warm-water Paleo-Tethyan current along the northern margin of Gondwana (Brenckle *et al*., 2009; Bahrammanesh *et al*., 2011) or by the narrowness of the Paleo-Tethys ocean allowing the connection of the peri-Gondwanan faunas with those of the southern margin of Laurassia (Zandkarimi *et al*., 2014; Vachard and Arefifard, 2015; Falahatgar *et al*., 2015). The paleogeographic position of Iran as part of Gondwana in the Early Carboniferous is also supported by the strong accordance of paleomagnetic poles of Iran and West Gondwana, during the Ordovician-Early Carboniferous (Muttoni *et al*., 2009). In fact, based on paleomagnetic data, Iran has a similar drifting history as the Arabian Plate from Late Ordovician to Early Carboniferous (Muttoni *et al*., 2009). The Ordovician-Carboniferous Gondwana apparent polar wander path shows that the Arabian Plate, as part of Africa, sustained an important plate motion, drifting from a high southern latitude in the Late Ordovician to a subequatorial latitude in the Early Devonian and then moved to intermediate southern latitudes in Late Devonian-Early Carboniferous times (McElhinny *et al*., 2003).

The faunal assemblages of the Late Carboniferous in Iran are clearly different from those of the peri-Gondwanan realm. They differ both in taxonomic composition as in climatic affinity. The Bashkirian-Moscovian and upper Gzhelian fusulinids in Alborz, central Iran and the Sabzevar zone indicate warm water conditions and are typical of the northern margin of the Paleo-Tethys. This may be linked to the rifting of Iran from the northern margin of Gondwana in early Late Carboniferous and its migration northwards. The movement of Iran toward the North, to a low latitude position with a warm climate is suggested by the occurrence of the Upper Carboniferous coal-bearing sandstones of the Sardar Formation in central Iran (Stöcklin *et al*., 1965). Coal is one of the most important paleoclimatic indicators of humid climate conditions. These sandstones are rich in quartz and poor in Al_2O_3 indicating humid to semi-humid climate. Moreover, the geochemical analyses of the Sardar Formation sandstones suggested a high degree of chemical weathering, indicative of warm and humid conditions during the deposition of these sandstones (Khanehbad *et al*., 2012). Besides, the paleogeographic reconstruction of Iran based on paleomagnetic data suggests a 30ºS position for Iran (Muttoni *et al*., 2009). The whole dataset suggests a warm and humid climate during the Late Carboniferous in central Iran.

Neotethyan rifting started in Carboniferous times along the eastern Gondwana margin from India (Garzanti and Sciunnach, 1997) to Oman (Al-Belushi *et al*., 1996). The continental breakup and the onset of the oceanic lithosphere formation followed from the Himalayas towards northern Oman in mid-Early Permian time (Garzanti, 1999; Angiolini *et al*., 2003).

Indications of the early phases of the Neo-Tethys opening during the Carboniferous and rifting of the Cimmerian terranes from northern Gondwana are recorded in the Misho magmatic complex and Ghushchi complex in northwestern Iran (Saccani *et al*., 2013; Dilek *et al*., 2014; Moghadam *et al*., 2014). Using SIMS U-Pb zircon ages, the Misho gabbros are dated at 356.7±3.4Ma and the gabbronorites and granites of the Ghushchi complex yield an age of ~320Ma. These igneous rocks may provide good evidence of the timing of the Neo-Tethys opening in Iran and cast doubts about the previous ideas of the rifting of Neo-Tethys in Iran in the Early Permian (Angiolini *et al*., 2007; Gaetani *et al*., 2009; Muttoni *et al*., 2009).

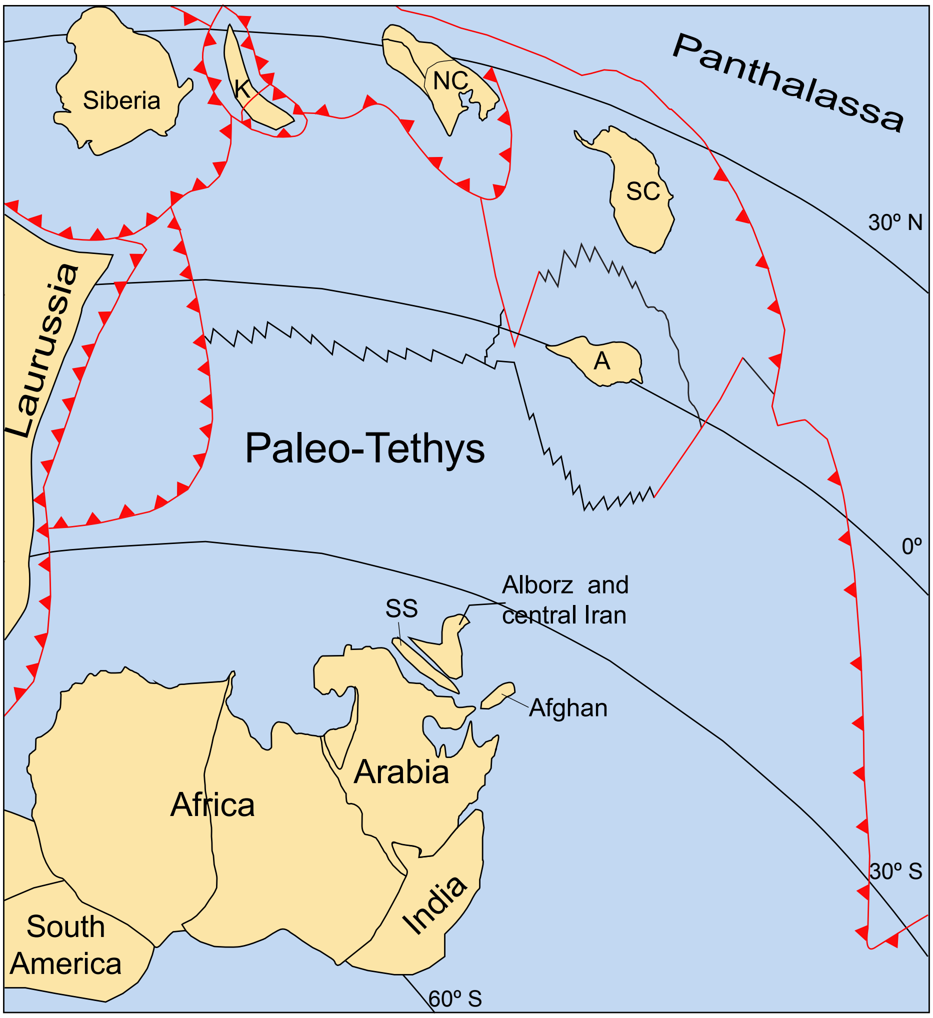


FIGURE 3. Early Carboniferous paleogeographic map simplified and modified from Domeier and Torsvik (2014) showing the location of Alborz and central Iran in the southern margin of the Paleo-Tethys in the Early Carboniferous. A: Annamia, K: Kazakhstania, NC: North China, SC: South China, SS: Sanandaj-Sirjan.

Proofs about Carboniferous magmatic activities and extensional deformation, related to the Variscan orogeny are increasing in Iran. For instance, an angular unconformity below the Upper Carboniferous(?)-Lower Permian Faraghan Formation in the High Zagros Belt suggests a connection with the Variscan orogeny (Tavakoli-Shirazi *et al*., 2013). However, the North to North-East trending faults and tilted blocks related to this Variscan unconformity show no signal of compressional deformation. The Ghushchi complex and Khalifan A-type granites in northwestern Iran are thought to be in conjunction with crustal movements in an extensional tectonic setting (Moghadam *et al*., 2014). Zanchi *et al*. (2015), according to the radiometric ages of the trondhjemite dikes and stocks that intruded the accretionary wedge of the Anarak metamorphic complex in central Iran, it was proposed that the subduction of the Paleo-Tethys happened during the Late Carboniferous. These authors suggested that the Anarak metamorphic complex developed along the southern Eurasian margin and was part of an allochthonous crustal fragment belonging to the Variscan belt before the Cimmerian collision of Iran.

Therefore, the Neo-Tethys opening and rifting of Iran from the northern margin of Gondwana has probably occurred sometime between the latest Visean to early Late Carboniferous (Bashkirian) (Fig. 4). Evidence for this conclusion are: i) the northern Paleo-Tethyan affinity of the foraminiferal associations in the late Visean-late Sepukhovian in Alborz, ii) the unique similarity between the Bashkirian-Kasimovian and late Gzhelian fusulinid assemblages of Iran to the northern margin of the Paleo-Tethys and iii) the Carboniferous magmatic activities in northwestern Iran and normal faulting and tilted blocks in the High Zagros Belt which, taken together, support extensional deformation related to the Variscan orogeny.

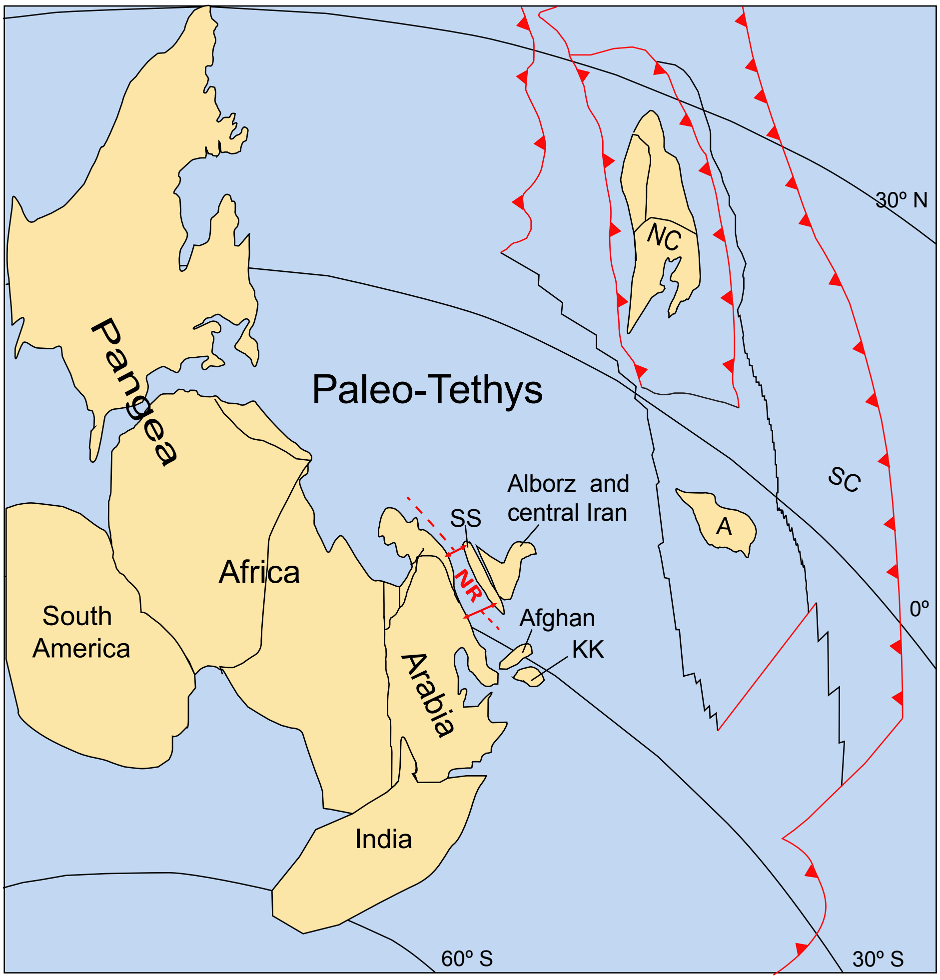


FIGURE 4. Late Carboniferous paleogeographic map simplified and modified from Domeier and Torsvik (2014) showing the rifting of Alborz and central Iran from the northern margin of the Gondwana in the Late Carboniferous. KK: Karakoram, NR: Neo-Tethys Ridge. For the other abbreviations see caption of Figure 3.

CONCLUSIONS

i) In the Early Carboniferous, foraminiferal associations in North and central Iran had a cosmopolitan character with elements from both the southern and northern margins of Paleo-Tethys. These faunal assemblages confirm the paleoposition of Iran in intermediate southern latitudes (ca. 30ºS) and still forming part of Gondwana. This foraminiferal-based paleogeographic reconstruction of Iran is consistent with the results of paleomagnetic data by Muttoni *et al.* (2009).

ii) In the Late Carboniferous, data from both smaller foraminifer and fusulinid assemblages in North and central Iran reveal the similarity of these faunas with their northern Paleo-Tethys counterparts. This can be inferred as a sign of the commencement of the separation of Iran from the northern margin of Gondwana and its movement towards the North.

iii) The movement of Iran towards the North and its low latitude position in the Gzhelian also is inferred from the occurrences of the coal-bearing sandstones of the Upper Carboniferous Sardar Formation.

iv) The Neo-Tethys opening in Iran occurred during the Late Carboniferous, based on the foraminiferal associations and magmatic activities in North-West Iran. This conclusion contrast with previous ideas on the onset of Neo-Tethys opening between northern Gondwana and the Cimmerian terranes during the Permian/ and or Triassic.

ACKNOWLEDGMENTS

The author is grateful to the highly constructive comments and critical reviews by Drs. Ian Sommerville, Daniel Vachard and an anonymous reviewer. Further, I wish to thank editor Prof. Carles Martín Closas for improving the English of my manuscript and the very careful editing of the final draft.

REFERENCES

Alavi, M., 1991. Tectonic map of the Middle East, Geological Survey of Iran. Tehran, Iran, Scale 1:5 000 000.

Al-Belushi, J.D., Glennie, K.W., Williams, B.P.J., 1996. Permo-Carboniferous glaciogenic Al Khlata Formation, Oman: A new hypothesis for origin of its glaciation. GeoArabia, 1(3), 389-404.

Altiner, D., Özgül, N., 2001. Carboniferous and Permian of the allochthonous terranes of the Central Tauride Belt, Southern Turkey. PaleoForams 2001, Guidebook, Ankara, 1-35.

Angiolini, L., Balini, M., Garzanti, E., Nicora, A., Tintori, A., 2003. Gondwanan deglaciation and opening of Neo-Tethys: The Al-Khlata and Saiwan formations of Interior Oman. Palaeogeography, Palaeoclimatology, Palaeoecology, 196(1-2), 99-123.

Angiolini, L., Gaetani, M., Muttoni, G., Stephenson, M.H., Zanchi, A., 2007. Tethyan oceanic currents and climatic gradients 300 MY ago. Geology, 35(12), 1071-1074.

Arefifard, S., 1997. Microbiostratigraphy of the Dorud and Ruteh Fm. in central Alborz. BSc Thesis. Tehran (Iran), Shagid Beheshti University, 155pp.

Assereto, R., 1963. The Paleozoic formations in Central Elburz (Iran) (Preliminary note). Rivista Italiana di Paleontologia e Stratigrafia, 69, 503-543.

Assereto, R., 1966. Geological Map of Upper Djadjerud and Lar Valleys (Central Elburz, Iran), scale 1:50 000, with explanatory notes. Istituto di Geologia dell'Universitá di Milano, 232pp.

Baghbani, D., 1993. The Permian Sequence in the Abadeh Region, Central Iran. Contributions to Eurasian Geology, Koroteev. University of South Carolina, Occasional Publications Earth Scientific Research Institute, N.S., 9B, 7-22.

Bagheri, S., Stampfli, G.M., 2008. The Anarak, Jandaq and Posht-e-Badam metamorphic complexes in central Iran: new geological data, relationships and tectonic implications. Tectonophysics, 451, 123-155.

Bahrammanesh, M., Angiolini, L., Antonelli, A.A., Aghababalou, B., Gaetani, M., 2011. Tournaisian (Mississippian) brachiopods from the Mobarak Formation, North Iran. GeoArabia, 16, 129-192.

Beavington-Penney, S.J., Racey, A., 2004. Ecology of extant nummulitids and other larger benthic foraminifera: Applications in palaeoenvironmental analysis. Earth-Science Reviews, 67(3-4), 219-265.

Bensh, F.R., 1962. Late Carboniferous and Early Permian fusulinids of Northern Fergana (in Russian). In: Stratigraphy and Paleontology of Uzbekistan. Akademiya Nauk Uzbekskoi SSR, Book 1, 187-252.

Bensh, F.R., 1972. Upper Paleozoic Stratigraphy and Fusulinids of South Fergana (in Russian). Tashkent, Fan Publishing House, 147pp.

Berberian, M., King, G.C.P., 1981. Toward a paleogeography and tectonic evolution of Iran. Canadian Journal of Earth Science, 18, 210-265.

Berra, F., Angiolini, L., 2014. The evolution of the Tethys region throughout the Phanerozoic: A brief tectonic reconstruction. In: Marlow, L., Kendall, C., Yose, L. (eds.). Petroleum systems of the Tethyan region. American Association of Petroleum Geologists Memoir, 106, 1-27.

Besse, J., Torcq, F., Gallet, Y., Ricou, L.E., Krystyn, L., Saidi, A., 1998. Late Permian to Late Triassic palaeomagnetic data from Iran: Constrains on the migration of the Iranian block through the Tethyan Ocean and initial destruction of Pangea. Geophysical Journal International, 135, 77-92.

Boudagher-Fadel, M.K., 2008. Evolution and Geological Significance of Larger Benthic Foraminifera. Developments in Palaeontology and Stratigraphy 21, Elsevier, 571pp.

Bozorgnia, F., 1973. Paleozoic Foraminiferal Biostratigraphy of Central and East Alborz Mountains. Iran. National Iranian Oil Company (Geological Laboratory), 4, 185pp.

Brady, H.B., 1873. On Archaediscus karreri, a new type of Carboniferous foraminifera. Annals and Magazine of Natural History, 12 (4), 286-290.

Brazhnikova, N.E., 1982. The genera Planoendothyra and Pseudoplanoendothyra Brazhnikova and Vdovenko gen. nov. (in Russian). Akademira Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik, Geologicheskiy instittut, Voprosy Mikropaleontologii, 25, 19-21.

Brazhnikova, N.E., Rostovtseva, L.F., 1967. The study of early Viséan Endothyranopsis of the Donets Basin and other regions. (In Fauna of the early Viséan sediments of the Great Donbas) (in Russian). Naukova Dumka, Kiev, 10-18.

Brenckle, P.L., Gaetani, M., Angiolini, L., Bahrammanesh, M., 2009. Refinements in biostratigraphy, chronostratigraphy, and paleogeography of the Mississippian (Lower Carboniferous) Mobarak Formation, Alborz Mountains, Iran. GeoArabia, 14, 43-78.

Bogush, O.I., Yuferev, O.V., 1966. Foraminifery karbona i permi Verkhoyanya (in Russian), 207pp.

Chernysheva, N.E., 1948. Some new species of foraminifera from the Visean of the Makarov District (in Russian). Academia Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik. Trudy Geologicheskii Instituta, 62, 246-250.

Conil, R., Lys, M., 1964. Matériaux pour l'étude micropaléontologique du Dinantien de la Belgique et de la France (Avesnois). Pt. 1, Algues et foraminifères; Pt. 2, Foraminifères (suite). Mémoires de l'Institut Géologique de l'Université de Louvain, 23, 1-372.

Cózar, P., 2002. Taxonomic value of the diaphanotheca/luminotheca in the classification of lower enthyroid Foraminiferida: creation of two new species of Pojarkovella. Geobios, 35, 283-291.

Cummings, R.H., 1955. New genera of foraminifera from the British Lower Carboniferous. Washington Academy of Sciences Journal, 45(1), 1-8.

Dain, L.G., 1953. Turneiellidy. In: Iskopaemye foraminifery Soyuz Sovetskikh Sotsialisticheskikh Respublik: Turneiellidy i Arkhedistsidy (Tournayellidae. In: Dain, L.G., Grozdilova, L.P. (eds.). Fossil foraminifers of the Union of Soviet Socialist

Republics, Tournayellidae and Archaediscidae) (in Russian). Trudy Vserossiiskii neftianoi nauchno-issledovatel'skii geologorazvedochnyi institut Leningrad, 74, 7-63.

Davydov, V.I., 1986. Upper Carboniferous and Asselian fusulinids of the Southern Urals. In: Chuvashov, B.I., Leven, E.Ja., Davydov, V.I. (eds.). Carboniferous-Permian Boundary beds of the Urals, Pre-Urals and Central Asia (in Russian). Moscow, Nauka Publishing House, 77-103.

Davydov, V.I., 2013. Climate fluctuations within the western Pangean tropical shelves – the Pennsylvanian/Permian record from benthic foraminifera. In: Lucas, S.G., DiMichele, W.A., Barrick, J.E., Schneider, J.W., Spielmann, J.A. (eds.). The Carboniferous-Permian Transition. Bulletin of the New Mexico Museum of Natural History and Science, 73-78.

Davydov, V.I., 2014. Warm water benthic foraminifera document the Pennsylvanian-Permian warming and cooling events – the record from the Western Pangea tropical shelves. Palaeogeography, Palaeoclimatology, Palaeoecology, 414, 284-295.

Davydov, V.I., Arefifard, S., 2007. Permian fusulinid fauna of Gondwanan affinity from Kalmard Region, East-Central Iran and its significance for the tectonics and paleogeography. Paleontologia Electronica, 10(2), 40pp.

Deprat, J., 1912. Etude des fusulinides de Chine et d'Indochine et classification des calcaires a fusulines. Memoires Service Geologique de l'Indochine, 1(3), 1-63.

Devuyst, F.-X., 2006. The Tournaisian-Visean boundary in Eurasia. Definition, biostratigraphy, sedimentology and early evolution of the genus *Eoparastaffella* (foraminifer). Thèse doctorat. Université Catholique de Louvain, 430pp.

Dilek, Y., Azimzadeh, Z., Saccani, E., Jahangiri, A., 2014. Early Carboniferous Magmatism and Rift Tectonics in the Western Sector of Paleotethysas Evidenced by the Misho Mafic Complex (NW Iran). Istanbul (Turkey), American Association of Petroleum Geologists International Conference and Exhibition, 14-17.

Domeier, M., Torsvik, T.H., 2014. Plate tectonics in the late Paleozoic. Geoscience Frontiers, 5, 303-350.

Dutkevich, G.A., 1934. On the stratygraphy of the Middle Carboniferous of the Urals (in Russian). Vsesoyuzniyi Neftianoi nauchno-issledovatel'skyi Geologorazvedochnyi Institute, Series A, 55, 1-41.

Dutkevitch, G.A., 1939. Order foraminifera. In: Likharev, B.K. (ed.). Atlas of Index Forms of Fossil Faunas of the USSR (in Russian). Central Geological and Prospecting Institute, Leningrad, 31-40.

Dzhenchuraeva, A.V., Okuyucu, C., 2007. Fusulinid Foraminifera of the Bashkirian-Moscovian boundary in the eastern Taurides, southern Turkey. Journal of Micropaleontology, 26, 73-85.

Falahatgar, M., Mosaddegh, H., Shirazi, M.P., 2012. Foraminiferal biostratigraphy of the Mobarak Formation (Lower Carboniferous) in Kiyasar Area, SE Sari, Northern Iran (English Edition). Acta Geologica Sinica, 86, 1413-1425.

Falahatgar, M., Vachard, D., Ahmadi Sakha, L., 2015. The Tournaisian (Early Carboniferous) of the Kahanag section (central Alborz; northern Iran); biostratigraphy with calcareous algae and foraminifers; palaeobiogeographic implications. Revue de Micropaléontologie, 58, 217-237.

Forke, H.C., 1995. The Carboniferous/Permian boundary in the Carnic Alps (Austria): additional observations on correlating fusulinid zones in the stratotype sections of the southern Urals and the Darvaz region with the Schulterkofel section. Permophiles, a Newsletter of Subcommission on Permian Stratigraphy, 26, 13-16.

Forke, H.C., 2002. Biostratigraphic subdivision and correlation of Uppermost Carboniferous/Lower Permian sediments in the Southern Alps: Fusulinoidean and conodont faunas from the Carnic Alps (Austria/Italy), Karavanke Mountains (Slovenia), and Southern Urals (Russia). Facies, 47, 201-275.

Forke, H.C., 2007. Taxonomy, systematics, and stratigraphic significance of fusulinoidean holotypes from Upper Carboniferous sediments (Auernig Group) of the Carnic Alps (Austria, Italy). In: Wong, Th.E. (ed.). Proceedings XVth International Congress on Carboniferous and Permian stratigraphy. Utrecht, 10–16 August 2003, Royal Netherland Academy of Arts and Sciences, 259-268.

Gaetani, M., Angiolini, L., Ueno, K., Nicora, A., Stephenson, M., Sciunnach, D., Rettori, R., Price, G., Sabouri, J., 2009. Pennsylvanian to Early Triassic stratigraphy in Alborz Mountains (Iran). In: Brunet, M.-F., Wilmsen, M., Granath, J.W. (eds.). South Caspian to Central Iran Basins. London, Geological Society, 312 (Special Publications), 79-128.

Garzanti, E., 1999. Stratigraphy and sedimentary history of the Nepal Tethys Himalayan passive margin. In: Upreti, B.N., Le Fort, P. (eds.). Advances on the Geology of the Himalaya – Focus on Nepal. Journal of Asian Earth Sciences, 17(5), 805-827.

Garzanti, E., Sciunnach, D., 1997. Early Carboniferous onset of Gondwanian glaciation and Neo-Tethyan rifting in southern Tibet. Earth Planetary Science Letters, 148(1), 359-365.

Golonka, J., 2002. Plate-tectonic maps of the Phanerozoic. Society for Sedimentary Geology, 72 (Special Publication), 21-75.

Gorgij, M.N., Leven, E.Ja., 2013. The First Findings of Fusulinids in the Sections of the Sabzevar Tectonic Block (Iran). Stratigraphy and Geological Correlation, 21(1), 8-17.

Groves, J., Kulagina, E.I., Villa, E., 2007. Diachronous appearance of the Pennsylvanian fusulinid Profusulinella in Eurasia and North America. Journal of Paleontology, 81, 227-237.

Grozdilova, L., Lebedeva, N.S., 1950. Some species of Staffella from the Middle Carboniferous of the western slope of the Ural Mountains (in Russian). Mikrofauna Soyuz Sovetskikh Sotsialisticheskikh Respublik, Vsesoyuznii Neftyanii Nauchno-Issledovatel' skii Geologo-Razvedochnii Instituta (VNIGRI), Trudy. New Series, 50(3), 5-46.

Grozdilova, L.P. and Lebedeva, N.S., 1954. Foraminifers from the Lower Carboniferous and Bashkirian stage of the Middle Carboniferous of the Kolvo-Vishera area (in Russian). Trudy Vsesesoyuznogo Neftyanogo Nauchno-issledovatel'skogo

156 Geologorazvedochnogo Instituta, Microfauna Soyuz Sovetskikh Sotsialisticheskikh Respublik, sbornik, 7(81), 4-236.

Howchin, W., 1888. Additions to the knowledge of the Carboniferous foraminifera. Journal of the Royal Microscopical Society of London, 1888(2), 533-542.

Huang, H., Shi, Y., Jin, X., 2015. Permian fusulinid biostratigraphy of the Baoshan Block in western Yunnan, China with constraints on paleogeography and paleoclimate. Journal of Asian Earth Sciences, 104, 127-144.

Kalvoda, J., 2002. Late Devonian-Early Carboniferous foraminiferal fauna: Zonations, evolutionary events, paleobiogeography and tectonic implications. Folia, Geologia, 39, 213pp.

Kalvoda, J., 2003. Carboniferous foraminiferal paleobiogeography in Turkey and its implications for plate tectonic reconstructions. Rivista Italiana di Paleontologia e Stratigrafia, 109(2), 255-266.

Kent, D.V., Muttoni, G., 2003. Mobility of Pangea: Implications for Late Paleozoic and Early Mesozoic Paleoclimate. In: Le Tourneau, P.M., Olsen, P.E. (eds.). The Great Rift Valleys of Pangea in Eastern North America. Tectonics, Structure, and Volcanism, New York, Colombia University Press, Volume 1, 11-20.

Khanehbad, M., Moussavi-Harami, R., Mahboubi, A., Nadjafi, M., Mahmudy Gharaie, M.H., 2012. Geochemistry of Carboniferous sandstones (Sardar Formation), East-Central Iran: implication for provenance and tectonic setting. Acta Geologica Sinica, 86(5), 1200-1210.

Kiessling, W., Fliigel, E., Golonka, J., 1999. Paleoreef maps: Evaluation of a comprehensive database on Phanerozoic reefs. Bulletin of American Association of Petroleum Geologists, 83(10), 1552-1587.

Kiparisova, L.P., Markovsky, B.P., Radchenko, G.P., 1956. Materialy po paleontologii: novye semeystva i rody. Vsesoyuznyy Nauchno-Issledovatel'skiy Geologicheskiy Institut, Novaya Seriya, Paleontologiya, 12, 1-354 (in Russian)

Kireeva, G.D., 1951. Stratigraphicheskoe polozhenie moskovskogo yarusa v razreze Donetskogo basseyna (na osnove raspredeleniya fusulinid) (in Russian). Bulleten' MOIP (Bulletin of Moscow Society of Naturalists), 26(3), 35-51.

Kobayashi, F., 2011. Two species of Profusulinella (P. aljutovica and P. ovata) Early Moscovian (Pennsylvanian) fusulines from southern Turkey and subdivision of primitive groups of the family Fusulinidae. Rivista Italiana di Paleontologia e Stratigrafia, 17(1), 29-37.

Krestovnikov, V.N. and Teodorovich, G.I., 1936. A new species of foraminifera of the genus Archaediscus from the middle Urals. Moskovskoye Obshchestva Ispytatelei Prirody Bulletin, Otdelenie Geologii, 44, Geologicheskaya Seria, 14 (1), 86-90 (in Russian).

Lee, I., 1936. Foraminifera from the Donetz Basin and their stratigraphical significance, Bulletin of Geological Society China, 16, 57-107.

Lee, J.S., Chen, S., Chu, S., 1930. Huanglung Limestone and its fauna. Memoirs of the National Research Institute of Geology, 9, 85-144.

Leven, E.Ja., 1993. Early Permian fusulinids from the Central Pamir. Rivista Italiana di Paleontologia e Stratigrafia, 104(1), 3-42.

Leven, E.Ja., Okay, A., 1996. Foraminifera from the exotic Permo-Carboniferous Limestone blocks in the Karakaya Complex, Northwestern Turkey. Rivista Italiana di Paleontologia e Stratigrafia, 102(2), 139-174.

Leven, E.Ja., Taheri, A., 2003. Carboniferous-Permian Stratigraphy and Fusulinids of East Iran. Gzhelian and Asselian Deposits of the Ozbak-Kuh Region. Rivista Italiana di Paleontologia e Stratigrafia, 109(3), 399-415.

Leven, E.Ja., Gorgij, M.N., 2006a. Upper Carboniferous-Permian Stratigraphy and Fusulinids from the Anarak Region, Central Iran. Russian Journal of Earth Sciences, 8, 1-25.

Leven, E.Ja., Gorgij, M.N., 2006b. Gzhelian Fusulinids First Discovered in Central Iran. Stratigraphy and Geological Correlation, 14(1), 19-29.

Leven, E.Ja., Gorgij, M.N., 2008. New Fusulinids of the Moscovian Stage Found in Iran. Stratigraphy and Geological Correlation, 16(4), 164-173.

Leven, E.Ja., Gorgij, M.N., 2011a. Kalaktash and Halvan fusulinid assemblages in the Padeh and Sang-Variz Sections (Halvan Mountains, Yazd Province, Central Iran). Stratigraphy and Geological Correlation, 19(2), 141-159.

Leven, E.Ja., Gorgij, M.N., 2011b. Fusulinids and Stratigraphy of the Carboniferous and Permian in Iran. Stratigraphy and Geological Correlation, 19(7), 687-776.

Leven, E.Ja., Gorgij, M.N., 2011c. First Record of Gzhelian and Asselian Fusulinids from the Vazhnan Formation (Sanandaj-Sirjan Zone of Iran). Stratigraphy and Geological Correlation, 19(5), 486-50.

Leven, E.Ja., Davydov, V.I., Gorgij, M.N., 2006. Pennsylvanian Stratigraphy and Fusulinids of Central and Eastern Iran. Palaeontologia Electronica, 9(1), 36pp.

Lipina, O.A., 1948. Foraminifery chernyshinskoi svity turneiskogo yarusa podmoskovskogo nizhnego karbona. Trudy Instituta Geologicheskikh Nauk, 62, 251-259.

Lipina, O.A., 1955. Foraminiferes de l'étage Tournaisian et de la partie superieure du Devonien de la region Volgo-ourallienne et du versant occidental de l'Oural moyen. Akademiya Sciences Union of Soviet Socialist Republics. Instituta Sciences Geologicheskikh, 70(163), 1-96.

Lipina, O.A., 1973. Zonal stratigraphy and paleogeography based on Tournaisian foraminifers (Zonalnaya stratigrafiya i paleogeografiya turne po foraminiferam) (in Russian). Voprosy mikropaleontologii, 16, 3-34.

Lys, M., Stampfli, G., Jenny, J., 1978. Biostratigraphie du Carbonifère et du Permien de l'Elbourz oriental (Iran du NE). Notes Laboratoire Paléontologie Université de Genéve, 10, 63-78.

Malakhova, N.P., 1953, New genus of foraminifera from the Lower Visean deposits of Urals (in Russian). Akademy of

Sciences, Union of Soviet Socialist Republics, Journal of Paleontology, 4, 111-112.

Malakhova, N.P., 1963. New foraminiferal species from lower Visean sediments of the Urals (in Russian). Paleontologicheskii Zhurnal, 4, 110-112.

Malakhova, N.P., 1973. Moskovsky yarus vostochnogo sklona Yuzhnogo Urala. Moscovian stage of the eastern slope of the South Urals (in Russian).Trudy Instituta Geologii i Geokimii, 8, 103-126.

Marfenkova, M.M., 1978. Foraminifery i stratigrafiya nizhnego i srednego vize Yuzhnogo Kazakhstana (Foraminifers and stratigraphy of the lower and middle Viséan of southern Kazakhstan). In: Dubatolov, V.N., Yuferev, O.V. (eds). Biostratigrafiya i paleobiogeografiya devona i karbona aziatskoi chasti SSSR (De vonian and Carboniferous biostratigraphy of the asiatic part of the Union of Soviet Socialist Republics) (in Russian). Akademiya Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik, Sibirskoe Otdelenie. Trudy Instituta Geologii i Geofiziki, 386, 78-99.

McElhinny, M.W., Powell, C.M., Pisarevsky, S.A., 2003. Paleozoic terranes of eastern Australia and the drift history of Gondwana. Tectonophysics, 362, 41-65.

Meissami, A., Termier, H., Termier, G., 1977. La phase transgressive mobarakienne (Tournaisien-Viséen) sur la bordure méridionale de la Téthys. Comptes Rendus, Paris, Académie des Sciences, 285, 1163-1165.

Melvin, J., Sprague, R.A., Heine, C.J., 2010. From bergs to ergs: the late Paleozoic Gondwanan glaciation and its aftermath in Saudi Arabia. In: Lopez-Gamundi, O.R., Buatois, L.A. (eds.). Late Paleozoic Glacial Events and Postglacial Transgressions in Gondwana. Geological Society of America, Boulder, 468 (Special Paper), 37-80.

Metcalfe, I., 1999. Gondwana dispersion and Asian accretion: an overview. In: Metcalfe, I. (ed.). Gondwana Dispersion and Asian Accretion (IGCP 321 Final Results Volume). Balkema, Rotterdam, 9-28.

Mikhailov, A., 1939. K kharakteristike rodov nizhnekamennougolnykh foraminifer territorii SSSR; nizhnekamennougolnye otlozhenii severozapadnogo kryla Podmoskogo basseina (On characteristic genera of Early Carboniferous foraminifers in territories of the USSR; the lower Carboniferous deposits of the northwestern limb of Moscow basin) (in Russian). Sbornik Leningradskogo Geologicheskogo Upraleniya , 3, 47-62.

Miklukho-Maklay, A.D. 1958. Phylogenie et la valeur stratigraphic des Lagenidae du Paleozoique. Doklady Akademiya Sciences Nauk Soyuz Sovetskikh Sotsialisticheskikh Respubli, 122(3), 381-483.

Moghadam, H.S., Li, X.-H., Ling, X.-X., Stern, R.J., Santos, J.F., Meinhold, G., Ghorbani, G., Shahabi, S., 2014. Petrogenesis and tectonic implications of Late Carboniferous A-type granites and gabbronorites in NW Iran: Geochronological and geochemical constraints. Lithos, 212-215, 266-279.

Möller, V.von., 1878. Die spiral-gewundenen Foraminiferen des rüssischen Kohlenkalkes (in Russian and Germany). Zapiski Imperatorskoi Akademii Nauk, 7(25), 1-147.

Moores, E.M., Twiss, R.J., 1995. Tectonics. New York, W.H. Freeman and Company, 415pp.

Murray, J., 2006. Ecology and Applications of Benthic Foraminifera. Cambridge, New York, Melbourne, Cambridge University Press, 426pp.

Muttoni, G., Mattei, M., Balini, M., Zanchi, A., Gaetani, M., Berra, F., 2009. The drift history of Iran from the Ordovician to the Triassic 2009. In: Brunet, M.-F., Wilmsen, M., Granath, J.W. (eds.). South Caspian to Central Iran Basins. London, Geological Society, 312 (Special Publications), 8-29.

Okuyucu, C., 2009. Systematics and biostratigraphic notes of the upper Moscovian-upper Gzhelian fusulinid foraminifers from the Anatolian Platform in the Southern Turkey. Geologica Balcanica, 38(1-3), 35-51.

Phillips, J., 1846. On the remains of microscopic animals in the rocks of Yorkshire. Geological and Polytechnic Society, West Riding, Yorkshire, 2, 274-285.

Pirlet, H., Conil, R., 1974. L'évolution des Archaediscidae viséens. Bulletin de la Société belge de Géologie, 82, 241-299.

Plummer, H.J., 1930. Calcareous foraminifera in the Brownwood Shale near Bridgeport, Texas. Bulletin University of Texas Bureau o Economic Geology and Technology, 3101, 5-21.

Potievskaya, P. D., 1964. Some fusulinids and small foraminifers of the Bashkir sediments of the greater Donets Basin (in Russian). Akademiya Nauk Ukrainskoi RSR. Trudy Instituta Geologicheskikh Nauk, Seriya Stratigrafii i Paleontologii, 48, 31-59.

Poty, E., Devuyst, F.-X., Hance, L., 2006. Upper Devonian and Mississippian foraminiferal and rugose coral zonations of Belgium and northern France: A tool for Eurasian correlations. Geological Magazine, 143, 1-29.

Prelevi, D., Jacob, D.E., Foley, S.F., 2013. Recycling plus: A new recipe for the formation of Alpine-Himalayan orogenic mantle lithosphere. Earth and Planetary Science Letters, 362, 187-197.

Prothero, D., 2013. Bringing Fossils to life: An introduction to Paleobiology. Columbia University Press, Third Edition, 672pp.

Putrja, F.S., Leontovich, G.E., 1948. Contribution to the study of the Middle Carboniferous fusulinids from the Volga region near Saratov (in Russian). Bulleten Moskovskogo Obshestva Ispytatelei prirody, otd-nie geologii, 23, 11-45.

Qiao, L., Falahatgar, M., Shen, S.-Z., 2016. A lower Visean (Carboniferous) brachiopod fauna from the eastern Alborz Mountains, northern Iran, and its palaeobiogeographical implications. Geological Journal, 52(2), 317-326. DOI: 10.1002/gj.2759

Rauser-Chernousova, D.M., 1938. Upper Paleozoic foraminifers of the Samara Bend and Trans-Volga Region (in Russian). Trudy Geologicheskogo Instituta, Akademiya Nauk SSSR 7, 69-160.

Rauser-Chernousova, D.M., 1948. Some new species of foraminifers from the Lower Carboniferous deposits of the Moscow Basin. In: Rauser-Chernousovam, D.M. (ed.). Stratigraphy and foraminifers of the Lower Carboniferous of the Russian Platform and the Cis-Ural region (in Russian). Akademiya Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik, Instituta Geologicheskikh Nauk. Trudy Geologicheskaya Seriya, 19(62), 227-238.

Rauser-Chernousova, D.M., 1953. Periodichnost' v razvitii foraminifer verkhnego paleozoya i ee znachenie dlya raschleneniya I sopostavleniya razrezov. Materialy paleontologicheskogo soveshchaniya po paleozoyu, 1951 (in Russian). Izdatelstvo Akademiya Nauk SSSR, Moskva, 139-160.

Rauser-Chernousova, D.M., Fursenko, A.V., 1937. Determination of foraminifera from the oil-producing regions of the Union of Soviet Socialist Republics (in Russian). Glavnova Redaktsya Gorno-Toplivnoi Literatury Leningrad, Moskova, 315pp.

Rauser-Chernousova, D.M., Kulik, E.L., 1949. Ob otnoshenii fusulinid k fatsiyam i o periodichnosti ikh razvitiya (in Russian). Izvestiya Akademii Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik, seriya geologicheskaya, 131-138.

Rauser-Chernousova, D.M., Belyaev, G.M., Reitlinger, E.A., 1936. Verkhnepaleozoyskiye foraminifery Pechorskogo kraya (Late Palaeozoic foraminifers from the Pechora territory) (in Russian). Trudy Polyarnoy komissii, 28, 152-232 .

Rauser-Chernousova D. M., Beljaev G.M., Reitlinger E.A., 1940. On Carboniferous foraminifera of the Samara Bend (in Russian). Geological Oil Institute, Transactions, new series, 7, 1-87.

Rauser-Chernousova, D.M., Gryzlova, N.D., Kireeva, G.D., Leontovich, G. E., Safonova, T.P., Chernova, E.I., 1951. Middle Carboniferous fusulinids in the Russian Platform and adjacent area (in Russian). Nauka, Moscow, 380pp.

Reitlinger, E.A., 1949. An account of the smaller foraminifera in the lower part of Middle Carboniferous in the central Ural and Kama regions (in Russian). Akademia Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik, Isvestia Seria Geologii, 6, 149-164.

Reitlinger, E.A., 1950. Foraminifera from the Middle Carboniferous deposits of the central part of the Russian Platform (excluding family Fusulinidae) (in Russian). Akademia Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik. Trudy Institut Geologicheskii Nauk, 126 (47), 1-127.

Reitlinger, E.A., 1971. Some problems of systematics in the light of evolutions of the Upper Paleozoic foraminifera (in Russian). Questions of Micropaleontology, 14, 3-16.

Reitlinger, E.A., 1975. Paleozoogeografiya vizeyskikh i rannenamyurskikh basseynov po foraminifersm. Paleozoogeography of Visean and early Namurian basins based on foraminifers (in Russian). Voprosy Mikropaleontologii, 18, 3-20.

Reitlinger, E.A., 1980. The problem of the boundary between the Bogdanovsky and Krasnopolyansky horizons (foraminifers of the Homoceras Zone) (in Russian with English summary). Akademiya Nauk SSSR, Voprosy Mikropaleontologii, 23, 23-38.

Rosovskaya, S.E. 1950. The Triticites genus, its development and stratigraphic significance (in Russian). Transaction of Paleontological Institute of Academy Sciences of the Union of Soviet Socialist Republics, 26, 3-79.

Ross, C.A., Ross, J.R.P., 1985. Carboniferous and Early Permian biogeography. Geology, 13, 27-30.

Ruban, D.A., Al-Husseini, M.I., Yumiko, I., 2007. Review of Middle East Palaeozoic plate tectonics. GeoArabia, 12(3), 35-56.

Rui, L., Ross, C.A., Nassichuk, W.W., 1991. Upper Moscovian (Desmoinesian) Fusulinaceans from the type section of the Nansen Formation, Ellesmere Island, Arctic Archipelago. Bulletin of Geological Survey of Canada, 418, 1-121.

Rumyuntseva , Z.S., 1970. Stratigraphy and Foraminifera of the Namurian and Lower Bashkirian deposits of the Tchatkal Mountain System. In: Biostratigmphy of sedimentary formations of Uzbekistan (in Russian). Minisrerstvo Geologii Uzbekskoi Soyuz Sovetskikh Sotsialisticheskikh Respublik. Tashkentskii Geologo-Razvedochnii Trest. Tashkent ge ologii. Kompleksnaya Geologos' emochnaya poiskovaya eksped iciya. lzdatel' stvo Nedra, 9. 138-184.

Saccani, E., Azimzadeh, Z., Dilek, Y., Jahangiri, A., 2013. Geochronology and petrology of the Early Carboniferous Misho Mafic Complex (NW Iran), and implications for the melt evolution of Paleo-Tethyan rifting in Western Cimmeria. Lithos, 162-163, 264-278.

Schellwien, E., 1908. Monographie der Fusulinen. 1. Die Fusulinen des russich-arktischen Meeres- gebietes. Palaeontographica, 55, 45-94.

Schellwien, E., 1909. Monographie der Fusulinen. Teil I: die Fusulinen des russischarctischen Meeresgebietes. Paleontographica, 55, 145-194.

Schlykova, G.N., 1948. Upper Carboniferous fusulinids of Samara Bend (in Russian). Trudy Vsesoyuznogo Neftyanogo Nauchno-issledovatelskogo Geologorazvedochnogo Instituta novaya seriya, 31(1), 109-135, Izdatelstvo Gostoptekhizdat, Moscow and Leningrad.

Schubert, R.J., 1921. Paleontologische daten zur Stammesgeschichte der Protozoen. Palaontogische Zeitschrift (1920), 3, 129-188.

Scotese, C., 2004. Cenozoic and Mesozoic paleogeography: Changing terrestrial biogeographic pathways. In: Lomolino, M.V., Heaney, L.R. (eds.). Frontiers of Biogeography: New Directions in the Geography of Nature. Sunderland (Massachusetts), Sinauer Associates, Inc. Publishers, 9-26.

Scotese, C.R., Langford, R., 1995. Pangea and the Paleogeography of the Permian, In: Scholle, P.A., Peryt, T.M., Ulmer-Scholle, D.S., (eds.). The Permian of Northern Pangea. Berlin, Springer-Verlag, volume 1, 3-19.

Sengör, A.M.C., 1984. The Cimmeride orogenic system and the tectonics of Eurasia. Geological Society of America, 195 (Special Publication), 1-82.

Sengör, A.M.C., 1990. A new model for the Late Palaeozoic-Mesozoic tectonic evolution of Iran and implications for Oman. Geological Society of London, 49 (Special Publication), 797-831.

Simonova, Y.A., Zub, B.B., 1975. Novye predstaviteli semeitsva Quasiendothyridae iz sdrene-verkhnevizeiskikh otlozhenii severnogo Tian-Shanya iMalogoKaratau (New representatives of the family Quasiendothyridae from the middle-late Viséan of northern Tian-Shan and Lesser Kara-Tau) (in Russian). Trudy Kazakhskiy Politekhnicheskikh Instituta Geologiya, 9, 19-35.

Solovieva, M.N., 1986. Fusulinid Zonation in the Moscovian Stage as inferred from re-examination of Stratotypes of the Internal Stage Subdivisions. Voprosy Mikropaleontologii, 28, 3-23 (in Russian).

Staff Von, H., Wedekind, R., 1910. Der oberkarbone Foraminiferesapropelit Spitzbergens: Bulletin of the Geological Institute of Uppsala, 10, 81-123.

Stampfli, G., 1978. Etude géologique générale de l'Elbourz oriental au S de Gonbad-e-Qabus, Iran N-E. PhD thesis. Université de Genéve, Switzerland, 329pp.

Stampfli, G.M., 2000. Tethyan oceans. In: Bozkurt, E., Winchester, J.A., Piper, J.D. (eds.). Tectonics and Magmatism in Turkey and the Surrounding Areas. Geological Society of London, 173 (Special Publication), 173, 1-23.

Stöcklin, J., 1968. Structural history and tectonics of Iran: a review. American Association of Petroleum Geologists Bulletin, 52(7), 1229-1258.

Stöcklin, J., 1974. Possible ancient continental margins in Iran. In: Burk, C.A., Drake, C.L. (eds.). The Geology of Continental Margins. New York, Springer-Verlag, 873-887.

Stöcklin, J., Eftekhar-Nezhad, J., Hushmand-Zadeh, A., 1965. Geology of the Shotori Range (Tabas area, East Iran). Geological Survey of Iran, Report no. 3, 69pp.

Suleimanov, I.S., 1945. Some new species of small foraminifera from the Tournaisian of the Ishimbayevo oil bearing region. Akademiya Nauk Soyuz Sovetskikh Sotsialisticheskikh Respublik Doklady, 48(2), 124-127.

Tavakoli-Shirazi, S., de Lamotte, D.F., Wrobel-Daveau, J.C., Ringenbach, J.C., 2013. Pre-Permian uplift and diffuse extensional deformation in the High Zagros Belt (Iran): integration in the geodynamic evolution of the Arabian plate. Arabian Journal of Geosciences, 6, 2329-2342.

Thompson, M.L., 1942. New genera of Pennsylvanian fusulinids. American Journal of Science, 240, 403-420.

Torsvik, H.T., Cocks, L.R.M., 2004. Earth geography from 400 to 250Ma: a palaeomagnetic, faunal and facies review. Journal of the Geological Society of London, 161, 555-572.

Ueno, K., 2006. The Permian antitropical fusulinoidean genus Monodiexodina: Distribution, taxonomy, paleobiogeography and paleoecology. Journal of Asian Earth Sciences, 26(3-4), 380-404.

Ueno, K., Watanabe, D., Igo, H., Kakuwa, Y., Matsumoto, R., 1997. Early Carboniferous foraminifers from the Mobarak Foramation of Shahmirzad, Northeastern Alborz Mountains, Northern Iran. In: Ross, C., Ross, J.R.P., Brenckle, P.L. (eds.). Late Paleozoic Foraminifers: Their Biostratigraphy, Evolution, and Paleoecology; and the Mid-Carboniferous Boundary. Cushman Foundation Foraminiferal Research, 36 (Special Publications), 149-152.

Ueno, K., Arita, M., Meno, S., Sardsud, A., Saesaengseerung, D., 2015. An Early Permian fusuline fauna from southernmost Peninsular Thailand: Discovery of Early Permian warming spikes in the peri-Gondwanan Sibumasu Block. Journal of Asian Earth Sciences, 104, 185-196.

Vachard, D., 1980. Téthys et Gondwana au Paléozoique supérieur, les données afghanes: Biostratigraphie, micropaléontologie, paléogéographie. Documents et Travaux de l'institut géologique Albert de Lapparent, 2, 463pp.

Vachard, D., 1996. Iran. In: Wagner, R.H., Winkler-Prins, C.F., Granados, L.F. (eds.). The Carboniferous of the World III: The Former USSR, Mongolia, Middle Eastern Platform, Afghanistan and Iran. Instituto Tecnológico Geominero de España, Madrid, International Union of Geological Sciences Publication. 33, 491-521.

Vachard, D., Arefifard, S., 2015. Foraminifers and algae of the late Tournaisian-early Visean boundary interval (MFZ8-9) in the Gachal Formation (Central Iran). Revue de Micropaléontologie, 58, 185-216.

Vachard, D., Pille, L., Gaillot, J., 2010. Palaeozoic Foraminifers: Systematics, palaeoecology and responses to global changes. Revue de Micropaléontologie, 53, 209-254.

Vdovenko, M.V., 1971. New species and forms of the genus Eoparastaffella (in Russian). Paleontologicheskii Sbornik, 7(2), 6-12.

Vdovenko, M.V., 1972. New subgenera of Endothyra and Globoendothyra (in Ukranian). Dopovidi Akademiya Nauk Ukrain. Vidbitok, Kiiv, 106-109.

Villa, E., Ueno, K., 2002. Characteristics and Paleogeographic Affinities of the Early Gzhelian Fusulinoideans from the Cantabrian Zone (NW Spain). Journal of Foraminiferal Reseearch, 32(2), 135-154.

Wendt, J., Kaufmann, B., Belka, Z., Farsan, N., Karimi Bavandpour, A., 2005. Devonian/Lower Carboniferous stratigraphy, facies pattern and paleogeography of Iran. Part II. Northern and Central Iran. Acta Geologica Polonica, 55, 31-97.

Zanchi, A., Malaspina, N., Zanchetta, S., Berra, F., Benciolini, L., Bergomi, M., Cavallo, A., Javadi, H.R., Kouhpeyma, M., 2015. The Cimmerian accretionary wedge of Anarak, Central Iran. Journal of Asian Earth Sciences, 102, 45-72.

Zandkarimi, K., Najafian, B., Vachard, D., Bahrammanesh, M., Vaziri, S.H., 2014. Latest Tournaisian–late Visean foraminiferalforaminiferal biozonation (MFZ8–MFZ14) of the Valiabad area, northwestern Alborz (Iran): geological implications. Geological Journal, 51, 125-142.

Zandkarimi, K., Vachard, D., Cózar, P., Najafian, B., Hamdi, B., Mosaddegh, H., 2017. New data on the Late Visean-Late Serpukhovian foraminifers of northern Alborz, Iran (biostratigraphic implications). Revue de Micropaléontologie. DOI: 10.1016/j.revmic.2016.11.003

Zaninetti, L., Altiner, D., 1979. La famille des Archaediscidae (Foraminifères): analyse taxonomique et propositions pour une nouvelle subdivision. Archives des Sciences, Genève, 32, 163-175.

Zhang, W., Chen, P.-J., Palmer, A.R., 2003. Biostratigraphy of China. Beijing, Science Press, 599pp.

Manuscript received September 2016;
revision accepted March 2017;
published Online May 2017.