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Sequential disappearance of Permian Rugosa in Iran and Transcaucasus, West Tethys

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Abstract: At the end of the Permian, many Palaeozoic organisms, including the Rugosa, became extinct. The marine Upper Permian yields relict groups within Rugosa. The Abadeh and Julfa regions, Iran and the Transcaucasus in the West Tethys are the important case areas for elucidating the end-Permian extinction patterns of Rugosa. Permian Rugosa in those areas showed distinct disappearance patterns morphologically and taxonomically.

The disappearance of *Yatsengia* and Wentzelellinae was succeeded by that of Waagenophyllinae, and Plerophyllidae were last to disappear. Each event boundary is marked by changes in sedimentary conditions and is associated with prominent biofacies changes in fusulinids, smaller foraminifers and so on, some of which were global and coeval.

The disappearance pattern of corals in Iran and the Transcaucasus was sequential in abundance and composition, owing to successive selection caused by progressively more adverse, local habitat changes under a pelagic to littoral. However, similar faunal successions appeared in different places and synchronous geological events, such as sea-level changes and volcanism, were prevailing over areas. Not only single and/or local environmental conditions, but global factors having multiple interactions could produce such characteristic faunal successions.

1. Introduction

The Rugosa went through many phylogenetic ups and downs, until they became extinct without leaving descendants by the end of the Permian. The timing of individual disappearance and its patterns were variable taxonomically and regionally, showing no obvious absolute trend. Flügel (1970), however, discussed the faunal succession of the Permian Rugosa from a morphological viewpoint, and he concluded that cerioid, fasciculate, and finally solitary corals having simple morphologies disappeared. Similar trends have been pointed out in local Permian faunas [*e.g.*, Iranian-Japanese Research Group (referred to as IJRG hereafter), 1981; Kato and Ezaki, 1986; Ezaki, 1991]. This trend may be a reflection of local and global factors and their changes (Fedorowski, 1989).

Late Permian corals have been reported from Iran and the Transcaucasus (*e.g.*, Iljina, 1965; Flügel, 1968, 1971; Kropatcheva, 1989). Very recently, Ezaki (1991) described the Permian corals of the Abadeh and Julfa regions, Iran in detail. The Middle Permian fauna is characterised by colonial waageno phyllids, whereas the Upper Permian fauna

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contains plerophyllids of high endemism at the specific level. The plerophyllids show marked morphological variations, but no phylogenetic relation to the scleractinian corals (Ezaki, 1989).

In this paper, I refer to one prominent faunal succession commonly observed among Permian Rugosa in the Abadeh and Julfa regions, Iran and the Transcaucasus. The disappearance pattern is considered in terms of litho- and biofacies changes on a local and global scale.

2. Permian strata

The Permian and Triassic strata of the Abadeh and Julfa regions and the Transcaucasus were studied in detail lithologically and biostratigraphically (*e.g.*, Ruzhentsev and Sarycheva eds., 1965; Stepanov *et al.*, 1969; Taraz, 1971, 1974; Teichert *et al.*, 1973; Leven, 1975; IJRG, 1981; Kotlyar and Zakharov eds., 1989). The Permian strata, for example, in the Abadeh region comprise ascendingly three formations, the Surmaq, Abadeh, and Hambast Formations (IJRG, 1981). The Middle Permian (the Surmaq Formation and the lower part of the Abadeh Formation) are characterised by bedded limestones having chert nodules and black shale with limestone intercalations, and they were interpreted to have been deposited in a basinal to open lagoonal environment. The Upper Permian (upper part of the Abadeh Formation and the Hambast Formation) are composed of bedded limestones having chert nodules, alternating beds of dark grey limestone and greenish shale, and brownish-red nodular limestones, deposited in a lagoonal environment (IJRG, 1981). A pelagic environment might appear temporarily in the Dorashamian age (Altiner *et al.*, 1980). A paraconformable relation between the Permian and the Triassic strata was confirmed by biostratigraphical evidence (IJRG, 1981). Stratigraphic changes in faunal abundance are summarised in Fig. 1.

Similar lithologic changes throughout the Permian in Abadeh, Julfa, and the Transcaucasus indicate similar sedimentological backgrounds. The lower boundary of the Dzhulfian (Upper Permian) is the base of the *Codonofusiella-Reichelina beds* (Ruzhentsev and Sarycheva eds., 1965). The uppermost part (*Pleuronodoceras* sp. nov. Zone) of the Dorasham Formation in the Transcaucasus is the late Changxingian age (Zakharov, 1985).

3. Disappearance events of Rugosa

Several species of micheliniids (*Protomichelinia*) occur throughout the succession, whereas the Rugosa show a gradient in occurrence (*e.g.*, IJRG, 1981; Ezaki, 1991; Figs. 2, 3 herein). Figure 2 summarises stratigraphic range of Permian corals in Iran and the Transcaucasus on the basis of their taxonomy. Figure 3 shows the timing of their disappearance according to each morphology. Three main disappearance events are discernible as follows:

1. Disappearance of *Yatsengia* and massive waagenophyllids (Wentzelellinae) having three or more orders of septa.
2. Disappearance of colonial waagenophyllids (Waagenophyllinae) having only two orders of septa.
3. Disappearance of simple solitary Rugosa (plerophyllids) which were the last survivors and remnants in these regions.

The final event, when the Rugosa totally disappeared, was the most important event in the rugosan extinction pattern, but the second event is also remarkable, because of the disappearance of Waagenophyllidae characteristic of the Permian Tethys. Each event boundary noted above is accompanied by distinct biofacies changes. The following (bio-)stratigraphical and sedimentological explanations are from the IJRG (1981) and Kotlyar and Zakharov eds. (1989).

The first event boundary (Surmaq/Abadeh Formations in Abadeh; Arpin/Khachik Formations in Transcaucasus) coincided with initial terrestrial muddy inflow into the basin and change from an open shelf to lagoon. The event is also characterised by the disappearance of larger fusulinids (Verbeekinidae) and distinct faunal changes in smaller foraminifers. The second boundary (early Dzhulfian: *Araxilevis* Beds / *Araxoceras tectum* Sub-

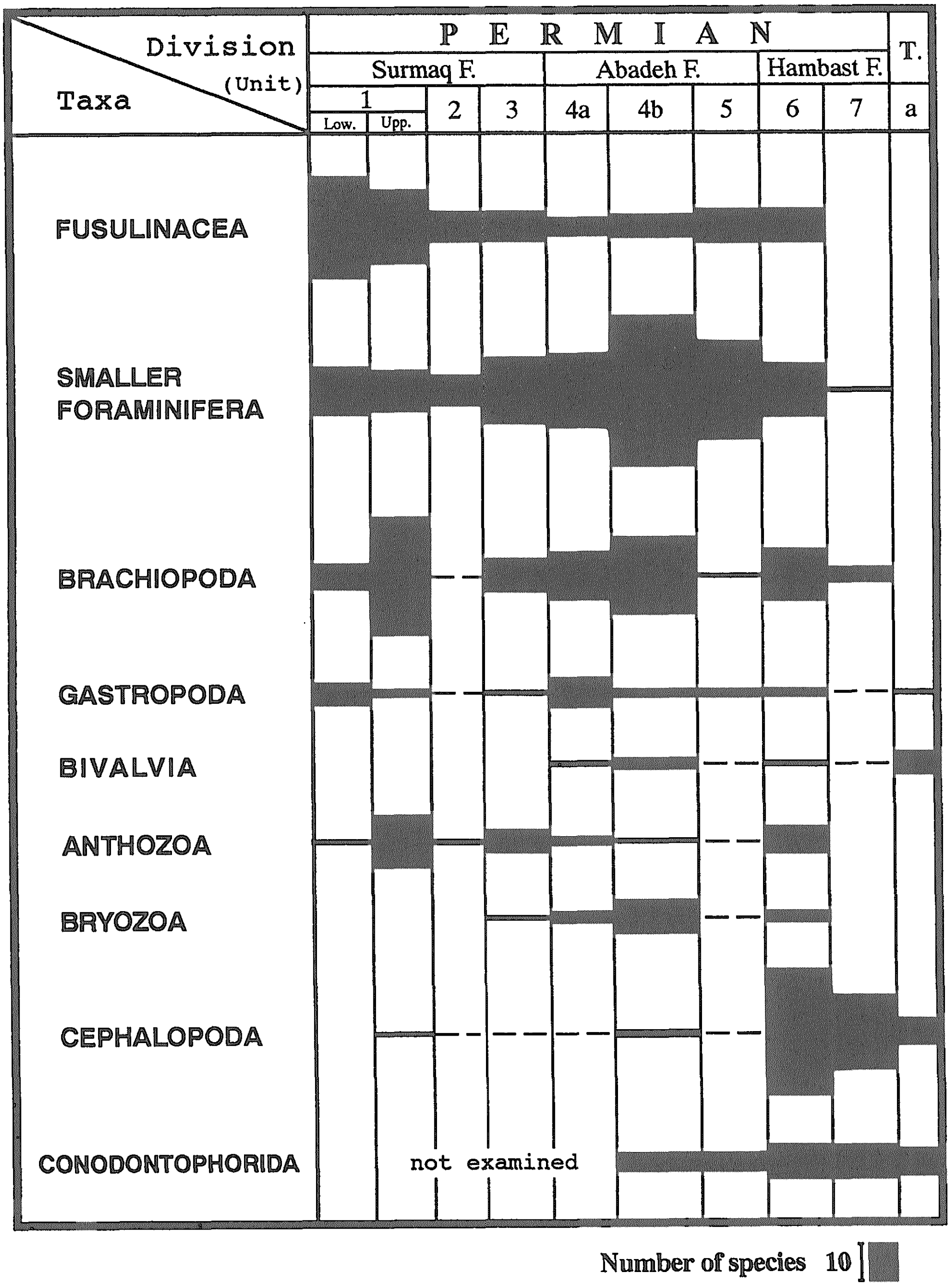

Fig. 1 Species richness in each horizon of the Permian in the Abadeh region, central Iran (modified from Iranian-Japanese Research Group, 1981). T.:Triassic

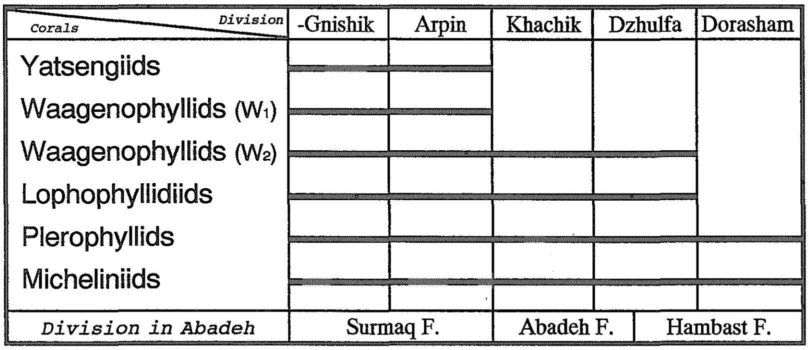

Fig. 2 Stratigraphic range of Permian coals in the Abadeh and Julfa regions, Iran and the Transcaucasus showing taxonomic changes.
See text for further explanation (Faunal data from Iljina,1965; Tchudinova,1965; Kropatcheva,1989; Ezaki,1991). Stratigraphic subdivisions are based on Leven (1975) and IJRG (1981). W_1:waagenophyllids (Wentzelellinae) having three or more orders of septa; W_2:waagenophyllids (Waagenophyllinae) having two orders of septa.

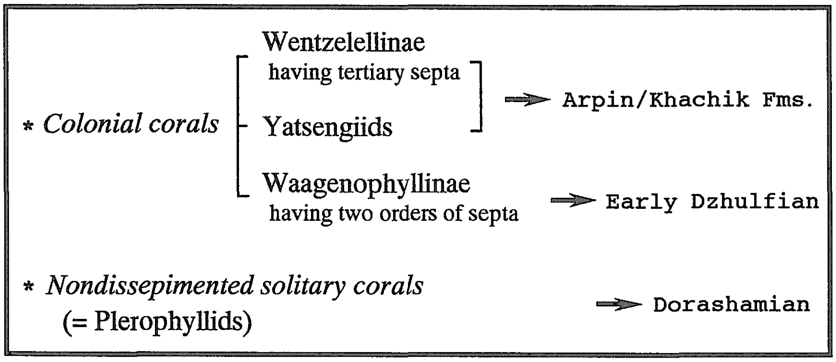

Fig. 3 Timing of disappearance of Rugosa ranked by morphology.
Each morphological group disappeared gradually in succession.

zone in Abadeh; *Pseudodunbarula arpaensis*-*Araxilevis intermedius* Zone / *Araxoceras latissimum* Zone in Transcaucasus) was correlated with a transition from an open to restricted marine environments. The lower part of the *Araxilevis* Beds is characterised by the appearance of abundant, nondissepimented solitary corals. However, the second boundary is distinguished by a conspicuous decrease in benthos, including diversified smaller foraminifera, fusulinids, and brachiopods, and by an increase in cephalopods and conodonts, thus showing a major faunal turnover. The similar faunal disappearance is observed in the upper most Permian, slightly below the boundary clayrock in South China (Yang *et al.*, 1991). The final stage (Dorashamian) was a time of environment having a low sedimentation rate and appreciable freshwater inflow, and of almost complete disappearance of benthos such as corals and brachiopods (Fig. 1).

4. Discussion

If considered only morphologically, similar faunal changes appeared in parallel geographically (Flügel, 1970), and they might have resulted from the prevalence of common ecological conditions or other factors. Underlying factors for those successions should be examined regionally and taxonomically for each area.

Benthic organisms, including Rugosa, flourished temporarily, but declined rapidly in the early Dzhulfian. The horizon is, however, marked by sudden increase in abundance and taxonomic diversity of pelagic organisms such as araxoceratid ammonoids and conodonts. The survival and disappearance patterns indicate the appearance of pelagic environment in response to a deepening of the habitat.

The faunal diversity still remained very low in the Dorashamian with the exception of cephalopods and conodonts, when the positive $\delta^{13}C$ values persisted (Holser and Magaritz, 1987). The Dorashamian benthic fauna, characterised by the small-sized solitary corals and brachiopods, was very meagre. Corals were strongly facies-dependent, and morphologically simpler corals were more flexible ecologically. Very simple solitary corals (*Pentaphyllum breviseptum* and *P. minimum*) survived in the peculiarly unfavourable habitats in the Upper Permian of Iran (Ezaki, in press). Morphological successions in Permian corals showing simpler morphologies disappearing later in time, were due to successive selections caused by progressively more adverse, local habitat conditions under a pelagic to littoral. Physicochemical changes, such as terrigenous influx, sea-level fluctuations, and salinity oscillation, might be probable factors.

Rugosa were already in decline during the early Late Permian, and the faunal successions were much affected by local habitat conditions. In South China, waagenophyllids occasionally occur up to the uppermost Permian (Changxingian) as the last survivors, different from the pattern in Iran and the Transcaucasus. That unique pattern is also taken into account, when considering environmental variations and their changes during Late Permian time (Ezaki, in prep.).

Global and coeval faunal successions are also observed in Khachikian fusulinids (disappearance of Verbeekinidae) and smaller foraminifers (distinct faunal changes), implying a mutual relation to worldwide habitat changes (IJRG, 1981). Worldwide sea-level fluctuations (Holser and Magaritz, 1987) and intermediate to acid volcanism (Yin *et al.*, 1992; Dickins, 1992) occurred during Late Permian time. Synchroneity of geological events and the presence of similar faunal changes in each taxon suggest that the faunal declines and sequential disappearance of Rugosa in Iran and the Transcaucasus can not be attributed only to a single or local change in environment, but to various factors having multiple interactions on a local and global scale.

Until now, studies on the end-Permian extinction have been based on near-shore marine organisms mainly from shallow carbonate and terrigenous facies. The extinctions were characteristic not only of those kinds of organisms, but also of offshore- and pelagic-dwelling organisms. Further investigation on biotic changes observed in pelagic and siliceous deposits are in progress to establish high-resolution stratigraphic correlations and to show what occurred on the earth at the end of the Palaeozoic.

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テーチス西部域，イランとトランスコーカサス地域のペルム紀四射サンゴ類の消滅様式

江崎洋一

要　旨

四射サンゴ類は，フズリナ類を始めとする他の多くの生物群とともにペルム紀末に絶滅する．テーチス西部域に位置するイランのアバデー・ジュルファ地域やトランスコーカサス地域からは，ペルム紀四射サンゴ類が層序的に連続して産出し，四射サンゴの消滅様式を探る上で重要な地域である．

ペルム紀四射サンゴ動物群の変遷には，形態・分類学上の顕著な消滅パターンが認められる．特定分類群の消滅に注目すると，*Yatsengia*とWentzelellinaeの消滅に引き続き，Waagenophyllinaeが消滅し，最後にPlerophyllidaeも消滅するという変遷が認められる．各々の消滅期は，地域的な岩相の変化期に良く対応し，また，フズリナ類や小型有孔虫類などの生物相の顕著な変化を伴っている．それらの中には，汎世界的に生じた変化も知られている．イランとトランスコーカサス地域でみられるペルム紀四射サンゴ類の漸進的な消滅様式は，遠洋～沿岸域での生息環境の悪化による差別的な分別に由来すると考えられる．しかし，類似の変遷は空間的に平行して認められ，また，世界的な海水準変動や火成活動などの地質事変の時期に生じている．地域的な，そして世界的な規模の要因が複雑に関連し，特有の消滅様式をもたらしたと考えられる．

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