

THE CAUSE OF BIOMASS EXTINCTION AT THE FRASNIAN-FAMENNIAN BOUNDARY, THE KERMAN PROVINCE SOUTHEASTERN, CENTRAL IRAN

M. Dastanpour* and A. Aftabi

Department of Geology, Faculty of Sciences, Shahid Bahonar University, Kerman, Islamic Republic of Iran

Abstract

About 35 samples were collected from lower and upper parts of the proposed Frasnian-Famennian boundary in three sections of Upper Devonian marine sediments of the Kerman province. The biostratigraphical and geochemical studies indicate that about 45% extinction of brachiopods probably caused by the Frasnian-Famennian bioevents, which is slightly higher than the rate of Devonian-Carboniferous extinction elsewhere. The results of isotopic carbon and oxygen isotope analysis ($\delta^{13}\text{C}\text{‰ VPDB}$ and $\delta^{18}\text{O}\text{‰ VPDB}$) show a sudden decrease at the proposed Frasnian-Famennian extinction boundary which is followed by positive values above this horizon. The negative excursion may indicate a biomass extinction due to either a meteorite impact or decay of organic matter. The isotopic variations are correlated with those of faunal changes and their extinctions in the area.

Keywords: Devonian; Extinction; Geochemical

Introduction

It is well known that the Frasnian-Famennian boundary represents one of the five major bioevents of Phanerozoic Eon. [9,12,13,17]. At the end of the Frasnian Stage, most of shallow water organisms disappeared [8]. Moreover, as has been proposed earlier [2,13], an asteroid impact at the Frasnian-Famennian boundary was responsible for the fundamental faunal changes between these two stages. Several significant papers have also been published on this subject [7,11].

However, no study in the central parts of Iran on this subject has been reported. This paper documents a new case study about the bioevent aspects of the Frasnian-Famennian boundary in Kerman Province, Iran.

The biomass of faunal is an important reservoir of carbon isotopes, which could change the productivity or rate of ocean turnover. Geologic time boundaries are based on biomass extinction events [10]. Stratigraphic boundaries are apparently associated with a depletion of ^{13}C in carbonate rocks across the time boundaries. This depletion indicates a perturbation in the exogenic

* E-mail: dastan@yahoo.com

carbon cycle, which might be related to the dissolved inorganic carbon in the ocean surface, decrease infertility in the upper ocean water mass, sudden mixing of the ocean water column bringing poisonous deep ocean water depleted in ¹³C to the surface, and increase in oxidation of organic carbon on the continental shelves or lands [7].

Regional Stratigraphy

A general view of the Devonian system for northern part of Kerman, southeast central Iran (Fig. 1) has been studied by one of us [4]. The upper Devonian marine sediments are well developed and widely distributed in north Kerman. These sequences have been systematically studied well over most parts of the Kerman region [3]. Commonly, they are approximately correlated with the Upper Devonian formations of the Bahram Limestone and the lower member of the Shishtu Formation in the Tabas area (Figs. 2 and 3).

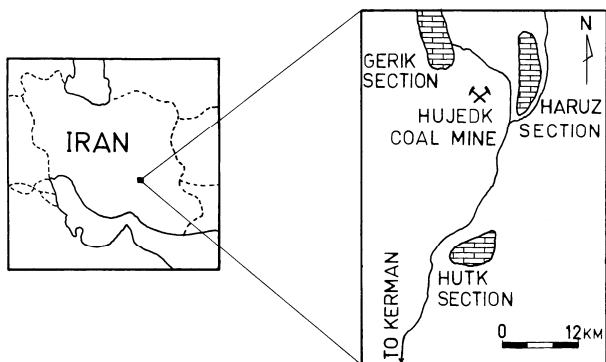


Figure 1. Locations of the study area.

Table 1. Results of carbon and oxygen isotope analyses from Hutk section

Sample No.	Carbon	Oxygen	Sample No.	Carbon
AD1a	-2.021	+0.5	AD8	+5.127
AD2b	-	+1	AD6c	+2.94
AD3a	+1.403	+1.5	AD5d	-4.48
AD3d	+4.924	+1.2	AD5c	-1.505
AD5b	+2.485	+0.75	AD5a	+2.527
AD6a	-1.254	-3	AD4b	+1.919
AD6b	+2.448	-1.2	AD4a	+2.476
AD7	+5.32	+1	AD3c	+2.054
AD2a	+2.446	-	AD3b	+0.36
AD1b	+1.93	-	AD3b	+3.081

In this paper the Frasnian-Famennian boundary has been investigated in three sections based on brachiopod extinction and appearance of Famennian faunas in northern Kerman (Fig. 1). The first and second sites are located in east and west of the Hojedk syncline about 65 km north of Kerman. The third section is located on the east side of the Hutk village, 30 km northeast of Kerman.

All of the above sequences were deposited in an epicontinental type environment [4]. The upper Devonian strata comprise about 200-320 m of limestone, argillaceous limestones, sandstone and shale. Brachiopods are the most common faunas in the Upper Devonian Stratigraphic sections in Kerman. The brachiopod faunas are followed by corals, palynomorphs, crinoids, bryozoans and tentaculites.

Methods

The Frasnian-Famennian boundary was proposed [1] by using the brachiopod faunas mass extinction and lithofacies changes in the Hutk section. Both biofacies and lithofacies of the Frasnian- Famennian boundary within the three studied sections are similar and correlative (Fig. 2).

Since the Upper Devonian strata in the Hutk section are well exposed and are the most complete Devonian sections in Kerman. Brachiopod samples were taken from this section for geochemical studies. Twenty rock samples from the lower and nineteen samples from the upper parts of proposed Frasnian-Famennian boundary were collected. All samples were studied in detail for lithostratigraphic and biostratigraphic purposes. Nineteen samples were sent to the Department of Geology, Oxford University for carbon isotope analysis. Eight samples were also analysed at the University of Liverpool for carbon and oxygen isotopes. Results of analyses are shown in Table 1 and Figure 4. As it has shown on Table 1 and Figure 4, figures of height above the proposed Frasnian-Famennian boundary are positive and below the boundary are negative.

Results and Discussion

Measurements of carbon indicate high increase in samples MP3d, AD7 and AD8 (4.929, 5.127 and 5.32% VPDB) at about 10 m below and above the proposed Frasnian-Famennian boundary. Variation of oxygen is comparable with carbon isotopes (Fig. 4). In general, amounts of carbon and oxygen increase from 20 m below upward to 15 m above the boundary.

The results of carbon and oxygen isotope analyses are shown in Table 1. According to literature [15,16],

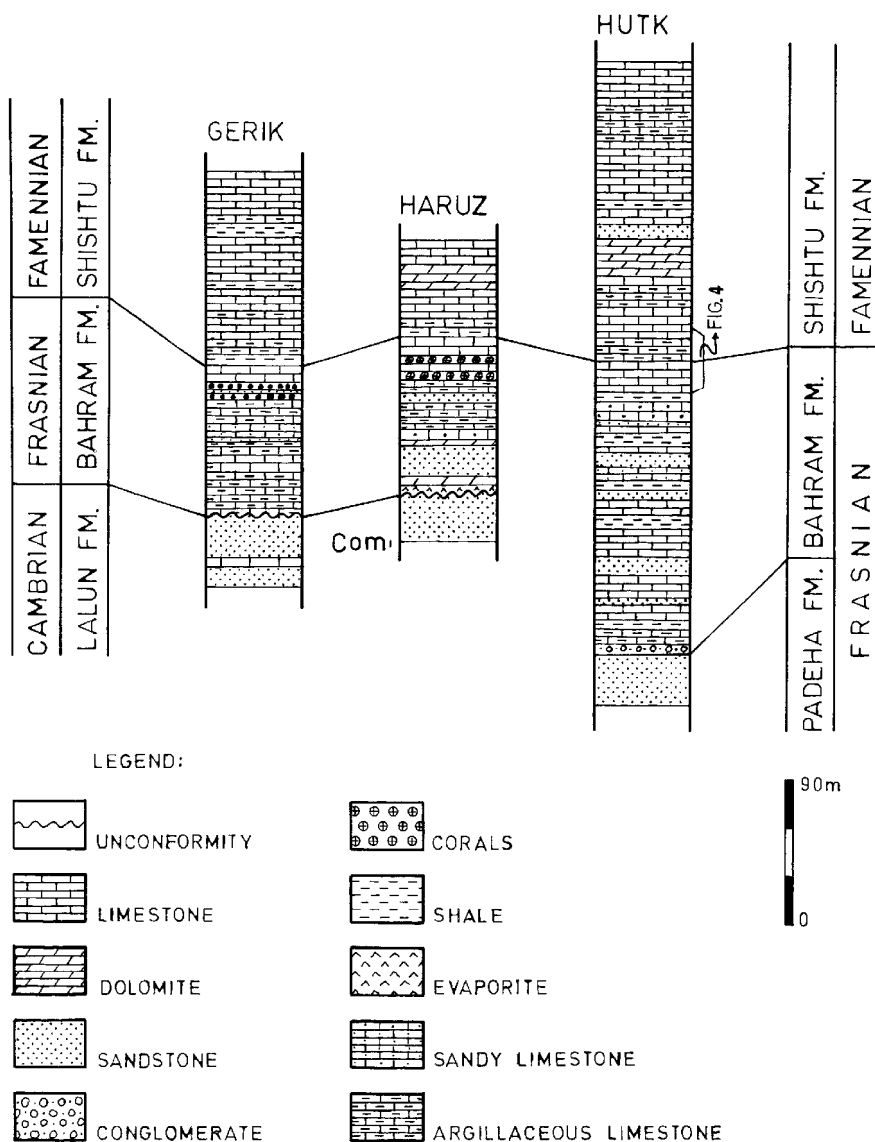


Figure 2. Devonian section in the study area north of Kerman (based on fossils).

the $\delta C^{13}\%$ ranges from -4.8 to +4 permil represents typical for shallow marine carbonate and bicarbonate. The oxygen isotope/values vary from -3 to + 1.5 % VPDB and indicate a shallow marine carbonate environment. Upper Devonian boundary stages are based on the conodont biozonation and extinctions in other part of the world. However, conodonts are rare in the Devonian strata of Kerman region, possibly due to the abundance of corals, crinoids and brachiopods. The shallow and turbulent condition of the upper Devonian environment in this region [5] also, might be unfavorable for the association of conodonts.

According to global researches at the end of the

Frasnian stage, most shallow water benthonics were disappeared. These include: (1) all shallow water corals [18]; (2) almost all stromatoporids; (4) several families of brachiopods [6,8]. These faunal diversifications were also reduced or dominated through the Frasnian-Famennian in Kerman region.

The most important elements discussed here are the brachiopods and corals which occur widespread over a vast area in the northern portion of the Kerman region with a rapid evolution within the Upper Devonian. The brachiopods of the Frasnian and Famennian stages are quite different from each other in Kerman region.

This study shows that by the end of the Frasnian in

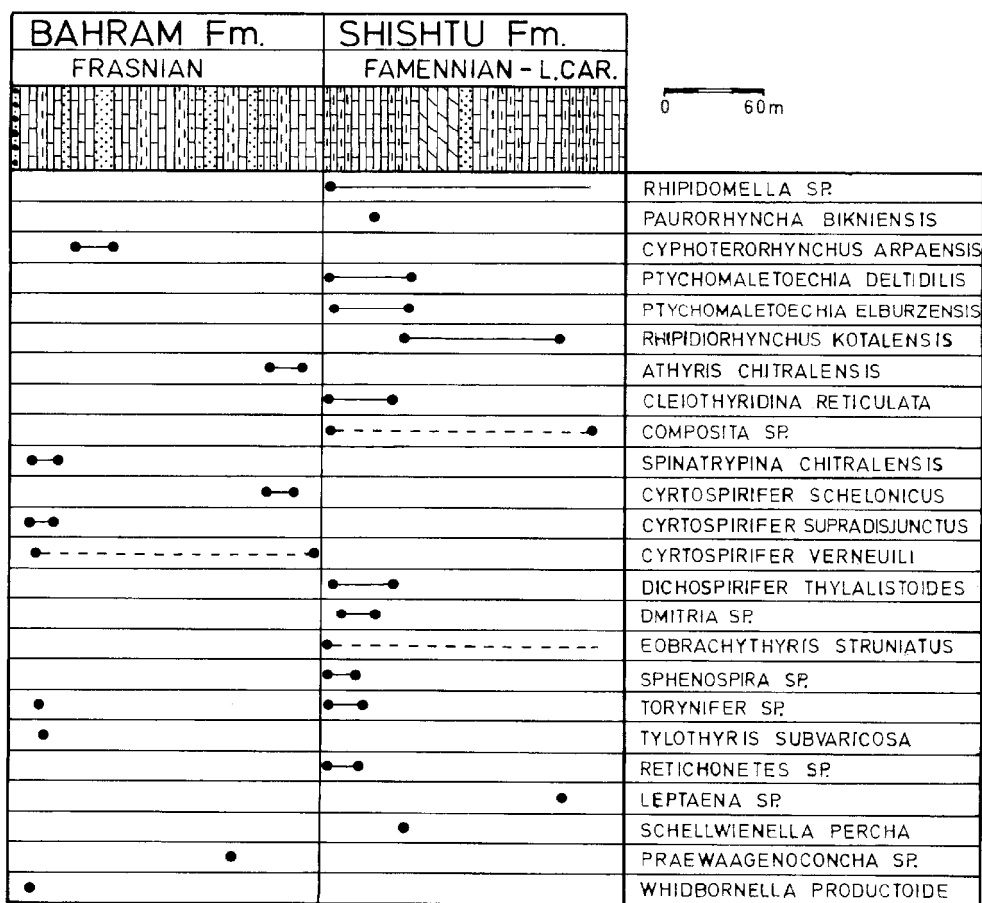


Figure 3. Stratigraphic sequence and brachiopod range chart of Hutk section.

the Hutk section, 13 taxa of the brachiopods mostly of *Cyrtospirifer* vanished, while the base of Famennian is marked by the sudden rise of totally 15 new brachiopod genera including: *Ptychomatetoechia elburzensis* and *Rhipidiorhynchus kotalensis* (Fig. 3).

The Frasnian-Famennian bioevents in the Hutk section exhibits about 45% extinction for the brachiopod genera, slightly higher than that of the Devonian Carboniferous extinction [14] and close to the Frasnian-Famennian extinction [5,6].

A recent study [5] on late Devonian corals indicates an extinction of most rugose and tabulate corals at or just above the Frasnian boundary in the Gerik area, 65 km north of Kerman. Nine taxa of corals including: *Argutastrea* sp., *Disphyllum caespitosum*, *Hexagonaria hexagona*, *Macgeea ponderosa* and *Alvolites* sp. were diminished by the Frasnian time.

Stromatoporoid fossils that have been associated wi-

thin the coral reefs of the Gerik and Haruz sections, in west and east of the Hojedk syncline, respectively were also disappeared before the Famennian time interval.

It is well known that the surface zone of the ocean magnifies the response to its $\delta^{13}C$ to the cyclical of carbon isotopes. Overturn of an anoxic ocean may introduce a negative excursion of $\delta^{13}C$ in the surface record [9].

The cause of mass extinction at the Frasnian-Famennian boundary in regard to the variation of carbon isotopes [6] indicate a sudden decrease at the proposed Frasnian-Famennian extinction boundary and then return to positive values above this horizon (Fig. 4). Like many parts of the world, this could explain a biomass reduction probably due to either a meteoritic impact or decay of organic matter or both [15]. The isotopic variations are well correlated with the faunal changes and their extinctions in the area (Figs. 3, 4).

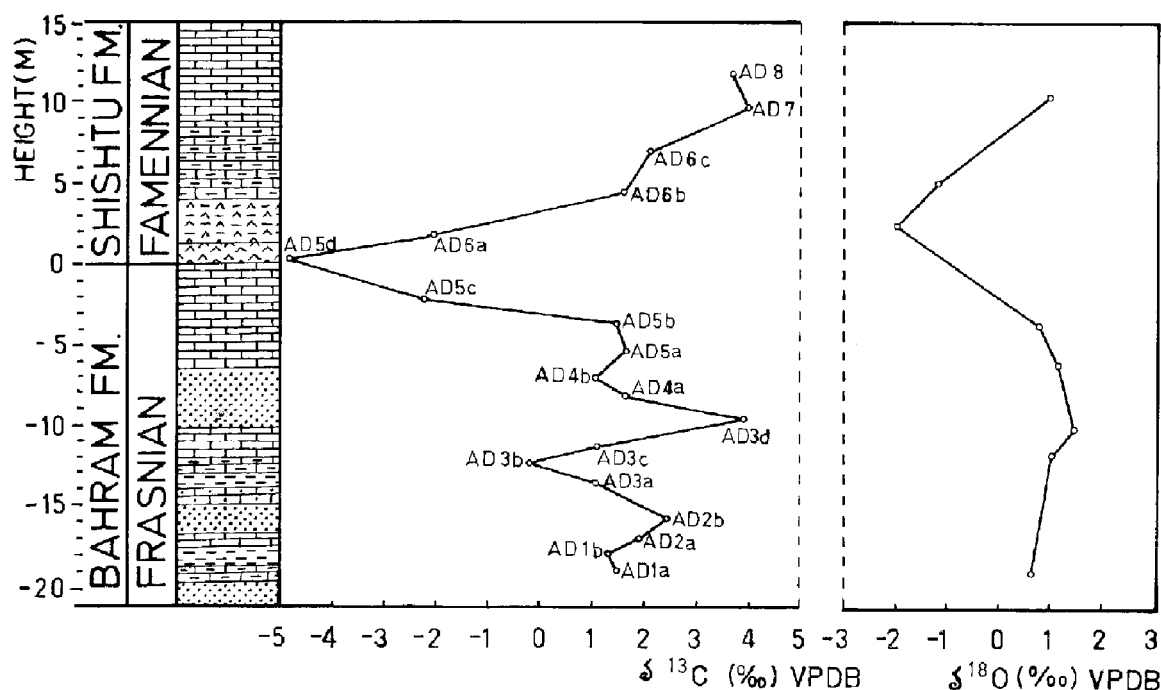


Figure 4. Carbon and oxygen isotope profile of Frasnian-Famennian boundary at the Hutk section. Numbers indicate No. of samples. 0 = proposed boundary; - = below the boundary.

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