Considerations over the Biostratigraphy of Jeirud Formation

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Abstract: Biostratigraphy is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them. Usually the aim is correlation, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section. In location of Type section (Jeirud village – north east of Tehran), There are four members (A, B, C and D) and they are with a thickness of 760 meters. Among four members in Jeirud Formation, only member A is pertaining to late Devonian which has been separated, with a clastic unit, with a thickness of 20 meters from other member (B, C and D) in early Carboniferous. Lower boundary of member A is type of parallel unconformity with lilthostraigraphic units (Mlia Formation) and is very index but there is no equal opinion about upper boundary. Also, based on advice from national stratigraphy committee in Iran, Jeirud Formation word is only equivalent to member of type section at the present which is representative of upper Devonian rocks in Central and western Alborz B, C, D members in Carboniferous can be compared with Mobarak Formation hence they do not have utility. This article aims to investigate the Considerations over the Biostratigraphy of Jeirud Formation, in addition to the use of basic biostratigraphy in different sediment types.

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1. Introduction

Biostratigraphy is a sub-discipline of sedimentary geology that relies on the physical zonation of biota, both in time and space, in order to establish the relative stratigraphic position (i.e. older, younger, same age) of sedimentary rocks between different geographic localities. Although the basic rules of biostratigraphic zonation were established in the late 18th to early 19th centuries in Europe (ultimately resulting in the development of the Relative Geologic Time Scale), the implementation of biostratigraphic techniques was in use in the United States during the early to mid-1800's. Some of the first geological surveys to be completed in the United States included those of the New York State Geological Survey. These surveys focused not only on New York's geological resources, but also emphasized the establishment of spatial and temporal relationships of stratigraphic units based on both lithologic and paleontologic composition. By the mid-1800's the New York Surveys had resulted in the development of a relative stratigraphic zonation based primarily on fossil distribution. New York localities are world famous for Cambrian through Devonian strata and fossils, but of particular importance to this website discussion is the contribution of the Ordovician rocks of central New York State to the establishment of a North American focused biochronology. The rocks found in the central New York Mohawk River Region, by definition of their fossil content, are now established as belonging to the Mohawkian Series of the Upper Ordovician Period. The following material focuses on key fossil taxa present in the Trenton Limestone, their distribution or occurrence within the overall succession of Upper Ordovician strata, and their role in the establishment of the Upper Ordovician time scale.

2. Biostratigraphy:

A Few Considerations

The goal of biostratigraphy is to use fossil occurrences within the rock record to establish correlations between time-equivalent rock strata as determined by the presence of a particular fossil species. Although the concept is generally straightforward, i.e. the presence of a specific fossil species in two geographic localities indicates the rocks containing the fossil specimens were deposited at about the same time, in practice biostratigraphic studies tend to be complex. The complexities of biostratigraphy result from aspects of the biology of the organisms including their environmental range, their evolutionary rates, as well as their tendency for preservation and probability of observation by the biostratigrapher.

Ultimately, the most rapidly evolving or short-lived, yet wide-ranging fossil taxa make the best biostratigraphic markers for correlation. If a given taxa is both wide-ranging and evolutionarily short-lived, and if it is robust enough to be preserved in the fossil record, then the taxa is often referred to as an index fossil. An index fossil identified in the rock record would constrain the age of the rock within which it is contained to a very specific interval of time when the organism lived. Fossil taxa used in biochronologic investigations rarely satisfy all aspects of the ideal index fossil. That is, they often violate one or more of the following rules:

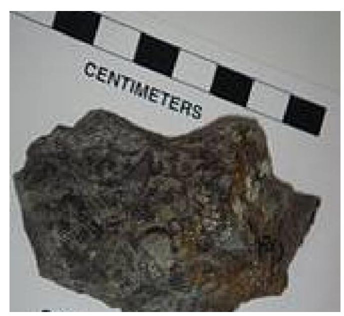
1) Must have a widespread distribution (fossils tend to be limited to a small region or are found only in a particular depositional environment as opposed to globally)
2) Must show rapid evolution (fossils change rapidly in preservable morphology so that distinctive identifiable species are easily recognized)
3) Must be present in substantial numbers (so that fossils can be observed by the biostratigrapher)
4), fossils should be robust mineralogically (so that depositional and diagenetic processes do not remove the fossils from the rock record).

Most often the best biostratigraphic markers or index fossils are taxa that live in the open water column either as free-floating plankton or as actively swimming nekton. Such organisms tend to be rapidly evolving, widely distributed and widely deposited. In contrast, benthic organisms which live on or very close to the seabottom, tend to be less widespread, fewer in numbers, and are typically found only in particular environments. Nonetheless, nektonic, planktonic, and benthic forms can be used to establish relative biostratigraphic age zonations. (http://www.mcz.harvard.edu, 2011)

3. Biostratigraphy

Biostratigraphy is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them. Usually the aim is correlation, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section. The fossils are useful because sediments of the same age can look completely different because of local variations in the sedimentary environment. For example, one section might have been made up of clays and marls while another has more chalky lime stones, but if the fossil species recorded are similar, the two sediments are likely to have been laid down at the same time.

Ammonites, graptolites, archeocyathids, and trilobites are index fossils that are widely used in biostratigraphy. Microfossils such as acritarchs, chitinozoans, conodonts, dinoflagellate cysts, pollen, spores and foraminiferans are also frequently used. Different fossils work well for sediments of different ages; trilobites, for example, are particularly useful for sediments of Cambrian age. To work well, the fossils used must be widespread geographically, so that they can occur in many different places. They must also be short lived as a species, so that the period of time during which they could be incorporated in the sediment is relatively narrow. The longer lived the species, the poorer the stratigraphic precision, so fossils that evolve rapidly, such as ammonites, are favored over forms that evolve much more slowly, like nautiloids. Often biostratigraphic correlations are based on a fauna, not an individual species, as this allows greater precision. Further, if only one species is present in a sample, it can mean that (1) the strata were formed in the known fossil range of that organism; (2) that the fossil range of the organism was incompletely known, and the strata extend the known fossil range. For instance, the presence of the fossil Treptichnus pedum was used to define the base of the Cambrian period, but it has since been found in older strata. (Gehling, 2001) Fossil assemblages were traditionally used to designate the duration of periods. Since a large change in fauna was required to make early stragtigraphers create a new period, most of the periods we recognize today are terminated by a major extinction event or faunal turnover.



The first reef builder is a worldwide index fossil for the Lower Cambrian
(Sengor, 1990; Beydoun, 1991)

Concept of stage

A stage is a major subdivision of strata, each systematically following the other each bearing a unique assemblage of fossils. Therefore, stages can be defined as a group of strata containing the same major fossil assemblages. French palaeontologist Alcide d'Orbigny is credited for the invention of this concept. He named stages after geographic localities with particularly good sections of rock strata that bear the characteristic fossils on which the stages are based.

Concept of zone

In 1856 German palaeontologist Albert Oppel introduced the concept of zone (also known as biozones or Oppel zone). A zone includes strata characterised by the overlapping range of fossils. They represent the time between the appearance of species chosen at the base of the zone and the appearance of other species chosen at the base of the next succeeding zone. Oppel's zones are named after a particular distinctive fossil species, called an index fossil. Index fossils are one of the species from the assemblage of species that characterise the zone. The zone is the fundamental biostratigraphic unit. Its thickness range from a few to hundreds of metres, and its extant range from local to worldwide. Biostratigraphic units are divided into six principal kinds of biozones:

- Taxon range biozone represent the known stratigraphic and geographic range of occurrence of a single taxon.
- Concurrent range biozone include the concurrent, coincident, or overlapping part of the range of two specified taxa.
- Interval biozone include the stata between two specific biostratigraphic surfaces. It can be based on lowest or highest occurrences.
- Lineage biozone are strata containing species representing a specific segment of an evolutionary lineage.
- Assemblage biozones are strata that contain a unique association of three or more taxa.
- Abundance biozone are strata in which the abundance of a particular taxon or group of taxa is significantly greater than in the adjacent part of the section.

4. Index fossils

To be useful in stratigraphic correlation index fossils should be:

- Independent of their environment
- Geographically widespread (provincialism/isolation of species should be avoided as much as possible)
- Rapidly evolving
- Abundant (easy to find in the rock record)
- Easy to preserve (Easier in low-energy, non-oxidized environment)
- Easy to identify (Gehling, 2001)

5. Jeirud Formation

In location of Type section (Jeirud village – north east of Tehran), There are four members (A, B, C and D) and they are with a thickness of 760 meters. Among four members in Jeirud Formation, only member A is pertaining to late Devonian which has been separated, with a clastic unit, with a thickness of 20 meters from other member (B, C and D) in early Carboniferous. Lower boundary of member A is type of parallel unconformity with lilthostraigraphic units (Mlia Formation) and is very index but there is no equal opinion about upper boundary.

Amplexograptus, a graptolite index fossil, from the Ordovician near Caney Springs, Tennessee.
(Aserto and et al., (1964))

Aserto and et al., (1964) has known member A, with a thickness of 355 meters in primitive studies, pertaining to late Devonian which has been composed of 140 meters of Plagioclase – bearing Basalt in middle and 55 meters of sand, conglomerate and fossils – bearing limestone at the top. Presence of about 2 meters of grey shale contains Acritarcs, pollen and spores pertaining to last epoch of Devonian (Stronian) in lower boundary of basaltic lavas has been resulted in introducing of Basaltic lavas, in 1960, as boundary between Devonian and Carboniferous and thickness of these strata in upper Devonian decreases from 335 to 140 meters. But Alavi Naiini (1372) and geologist B. R. G. M believe that suggestion of Aserto is more acceptable. Fossils and regional data and lateral elimination of basaltic lavas are emphasis on this belief. Because in areas where there is no Jeirud Formation (member A), Carboniferous has begun with quartzite of member B.

Also, based on advice from national stratigraphy committee in Iran, Jeirud Formation word is only equivalent to member of type section at the present which is representative of upper Devonian rocks in Central and western Alborz B, C, D members in Carboniferous can be compared with Mobarak Formation hence they do not have utility.

It is necessary to mention that one of characteristics of Jeirud Formation is containing of chlore – bearing carbonate apatite (Francolith) which have been observed as granular and or cement particularly in clastic beds and dark shale in lower bed of formation. In Shemshak Valley, Carat of phosphate – bearing beds is 8-20 % as P2O5. Even

though reservoirs of phasohate – bearing beds are economic but concentration process is difficult. Besids of Shamshak valley other section of Jeirud Formation (Firouz kuh, Zakin and Mobaralk Abad) are still symptoms of phosphate which can be compared with phosphate in Central Iran, Zagros and even some of adjacent countries).
(http://www.gsi.ir/newirangeology, 2011)

6. The use of basic biostratigraphy in different sediment types

Basic biostratigraphy is concerned with the recognition of fossils and the relative position of their occurrences in space and time. Various fossil groups can be found in different sedimentary environments. The two main environments are land (terrestrial) and sea (marine).

In terrestrial sediments, spores and pollen are the fossil group to use. Other fossil groups, such as vertebrates or other larger fossils, can only be used if the sediments samples are sufficiently large. In practice, this limits their use to outcrop samples. The limitation on the use of spore/pollen is the amount of oxidation experienced by the sediments after deposition. Oxygen will remove organic material (spores/pollen) from the sediments. Spores can be used in Devonian (approx. 400 myrs) to recent sediments, pollen in Upper Cretaceous (approx. 80 myrs) to recent sediments. Both can be found blown into marine environments in considerable amounts. In marine sediments, calcareous nannofossils are the most useful group for Jurassic (approx. 210 myrs) to recent sediments, since their preparation is cheap and the stratigraphic resolution which can be reached with them is high. Occasionally sediments can be leached of calcareous particles, however, which also removes calcareous nannofossils (for instance in deep sea sediments). Their use as environmental indicators is limited, although some species are known to be associated with warm or cold water masses.

Palynomorphs (dinoflagellates, acritarchs and tasmanites) can be used in Permian (approx. 260 myrs) to recent sediments and in most sediments types (though they tend to be rare in chalky limestone). Since their preparation includes the dissolution of the surrounding sediments, their use is more expensive than nannofossils. The possible stratigraphic resolution can be high. Recently, the use of organic grain size and shape as environmental indicators has been developed and is apparently useful, especially in sub-recent sediments. Foraminifera can be used in all marine sediments which have not be leached of calcareous material, i.e. from shallow marine to middle bathyal. Their stratigraphic resolution can be high and their association with certain depositional environments makes them good environmental (water depth) indicators. Foraminifera can be found in sediments of Carboniferous (approx. 360 myrs)to recent age. Their preparation cost is lower than that of palynomorphs, unless thin-sections have to be used. (http://strats.home.xs4all.nl/biostrat.htm, 2011)

7. Regional geologic setting

Alavi-Naini and Bolourchi (1973) reported that in the area north of Tabriz, sedimentary rocks are presumably of Early to Late Devonian in age (Muli and Ilanqareh Formations) that have transgressed on a Precambrian basement or on Lower Paleozoic sandstones and dolomites of the Lalun and Mila Formations and are in turn overlain by Permian platform dolomites of the Ruteh Formation. The Ilanqareh Formation in the study area conformably overlies the Muli Formation and underlies Jeirud (Devonian) or Ruteh (Permian) Formations.

Paleogeographic investigations indicate that at the time of deposition of Ilanqareh Formation (Devonian age), the northwest Iran was a part of the long and wide northern passive margin of Gondwanaland bordering the Paleo-Tethys Ocean (Sengor, 1990; Beydoun, 1991).

Stump et al., (1995) indicated that the Late Devonian to Early Carboniferous sediments are not uniformly distributed across the Arabian Peninsula due to uplift and erosion associated with the Hercynian Orogeny during the end of Devonian to Carboniferous. Also, regional comparison between Ilanqareh Formation of northwest Iran with the Upper Paleozoic formations in Syria, Iraq, Turkey and Saudi Arabia by Husseini (1991) indicates that during the Paleozoic times, North Africa and Arabia were part of a broad continental shelf margin and, furthermore, these areas were subjected to major intra-continental extension from Late Devonian to possibly Early Carboniferous and the Arabian and adjacent plates were structurally affected by a regional Hercynian tectonic event. (Najafzade et al., 2010)

8. Conclusion

Basic biostratigraphy is concerned with the recognition of fossils and the relative position of their occurrences in space and time. Various fossil groups can be found in different sedimentary environments. The two main environments are land (terrestrial) and sea (marine). Biostratigraphy is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them. Usually the aim is correlation, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section.

Based on advice from national stratigraphy committee in Iran, Jeirud Formation word is only equivalent to member of type section at the present which is representative of upper Devonian rocks in Central and western Alborz B, C, D members in Carboniferous can be compared with Mobarak Formation hence they do not have utility. It is necessary to mention that one of characteristics of Jeirud Formation is containing of chlore – bearing carbonate apatite (Francolith) which have been observed as granular and or cement particularly in clastic beds and dark shale in lower bed of formation.

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References:

[1]Gehling, James; Jensen, Sören; Droser, Mary; Myrow, Paul; Narbonne, Guy (March 2001). "Burrowing below the basal Cambrian GSSP, Fortune Head, New found land". Geological Magazine 138 (2): 213–218

[2]http://www.mcz.harvard.edu/Departments/InvertPaleo/Trenton/Intro/GeologyPage/Sedimentary%20Geology/biostrat.htm, Accessed in 2011.

[3] http://strats.home.xs4all.nl/biostrat.htm, Accessed in 2011.

[4]http://www.gsi.ir/newirangeology/Main/Lang_en/Page_21/FormationId_201/ErathemId_5/PeriodId_21/Action_ActionFormation/Stratigraphy.html, Accessed in 2011.

[5] Najafzadeh, Adel, Mahdi Jafarzadeh, and Reza Moussavi-Harami, Provenance and tectonic setting of Upper Devonian sandstones from Ilanqareh Formation (NW Iran), Revista Mexicana de Ciencias Geológicas, v. 27, núm. 3, 2010, p. 545-561.

[6] Beydoun, Z.R., 1991, Arabian Plate Hydrocarbon Geology and Potential: A Plate Tectonic Approach: American Association of Petroleum Gelogists, 33, 77 pp.

[7] Sengor, A.M.C., 1990, A new model for the late Palaeozoic-Mesozoic tectonic evolution of Iran and implications for Oman, in Robertson, A.H.F., Searle, M.P., Ries, A.C. (eds.), The Geology and Tectonics of the Oman Region: London, Geological Society of London, special publication, 49, 797-831.

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