USE OF VENN DIAGRAM IN QUANTITATIVE STRATIGRAPHIC STUDY

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ABSTRACT

A graphical method based on the concept of Venn diagram is applied for visualising the interrelationship between lithology and fossils, particularly the larger benthic foraminifers present in the Paleogene rocks around Jadva village in Western Kutch.

The Paleogene sedimentary rocks of the area are only a part of the universal set of Paleogene sedimentary rocks. The set of Paleogene sedimentary rocks of the area, in turn, has two major subsets, lithology and fossils i.e. a non-biogenic set and a biogenic one, respectively. These sets are plotted graphically and their relationship is inferred from geometric pattern. This general method with required modifications can be used for fossiliferous rocks of any area for the purpose of qualitative and quantitative stratigraphical studies; for unfossiliferous sequences, too, the method may be extended on the basis of different lithological, mineralogical and chemical subsets of the rock units.

INTRODUCTION

Venn diagram is a well-known diagrammatic as well as mathematical representation of the interrelationship between different sets and subsets of data (see Freund 1979). It may be drawn schematically with numericals imprinted on it or by graphical method. The latter also helps to bring out the relation between the elements of a set, or between the set and its subsets.

In stratigraphical studies, rocks and fossils are the two basic sets of data. The stratigraphy of an area may be represented by means of a Venn diagram by considering the stratigraphical sequence in vertical columns or its areal extent from different outcrop study. The Universal set is defined as the set of sedimentary rocks; the stratigraphical sequence, in question, is only a part of it. Different lithic units may be taken as its subsets, Fossils enclosed in litho-units are considered as constituent subsets of each rock unit. Fossils and aggregate of minerals are rock forming materials. Fossils stand for biogenic subsets, matrix and framework grain meterial falling into the categories of non-biogenic subsets.

The present note is an attempt to represent these stratigraphical information in a Venn diagram. The merit of the method, elaborated from that in Ghosh (1983; Unpubl. M.Sc. Thesis, C.U.) lies in its flexibility. It may

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even be extended to unfossiliferous sequences, whose lithological, mineralogical and chemical subsets of litho-units may be brought into consideration. For each different case, however, the sets should be defined properly before plotting them in a diagram.

The material is acquired from a study of Paleogene sediments of over 80 sq. km. area around Jadva in Western Kutch. In this area the larger benthic foraminifers are the most important, abundant and well preserved group of fossils. For this reason, population studies of these fossils are carried out and are considered within the biogenic sets. Other fossils like fragments of echinoids, bivalves etc., along with planktonic and benthonic smaller foraminifers, whose population study remains out of the present scope, are grouped with the matrix for the time being. The latter set, thus, does not remain a strictly non-biogenic set, at least for the present purpose. But in no way, it causes any difficulty in showing the relationship between a group of fossils and the lithology of the area.

BRIEF GEOLOGY

The village Jadva lies in the south-western part of the westerly convex outcrop belt of the Paleogene rocks in western Kutch. For the entire said belt, including Jadva area, Ray *et al.* (1984) recognize three formational units in the Paleogene sequence and name them informally as CE Suite (late Lower Eocene/early Middle Eocene) WLM Suite (Late Middle Eocene) and CLMC Suite (Oligocene), They form a conformable homoclinal sequence on a basalt basement, dipping south-westerly at low angle at Jadva. Further subdivisions of these units are not regionally mappable, though for the area they can be mapped in fair details. The correlation of these units with those of earlier authors is given in Table 1A, B and C in Ray *et. al.* (1984).

The generalized succession in the Jadva area is given below :—

CLMC Suite (Oligocne)	Brown Limestone Sandy Marlstone White Marlstone Lithoclastic Limestone
	..............?..............
WLM Sute (Late Middle Eocene)	White Limestone (With dolomitic/ marly limestone). Pale Yellow Marlstone.
	.........Conformable.........
CE Suite (? Late Lower Eocene-early Middle Eocene)	Green Marlstone/*N. obtusus* Marlstone/*Assilina* Marlstone. Variegated claystones-siltstones with gypsum and pyrite and mudstone boulderbed.
	......Non-conformity......
	Basalts

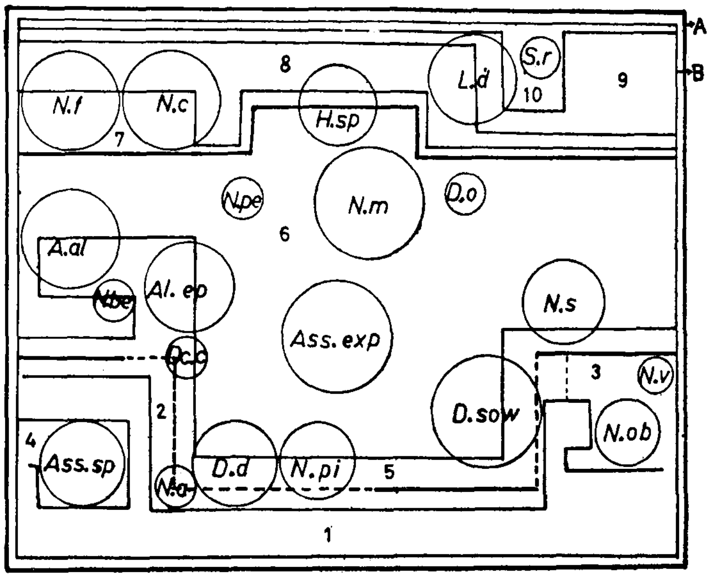

Figure 1 : Venn Diagram showing the rock units and larger benthic foraminiferal fossils, from around Jadva, western Kutch. Numbers refer to the rock-units as shown in the legend of Figure 2.

Fossil Index

A. al—Asterocyclina alticostata.
Al. ep—Alveolina elliptica var. *nuttalli.*
Ass. exp—Assilina exponens.
Ass. sp—Assilina sp.
D. d—Discocyclina dispansa.
D. o—D. omphalus.
D. sow—D. sowerbyi.
Dc. c—Dictyconoides cooki.
H. sp.—Heterostegina sp.
L. d—Lepidocyclina (Eulepidina) dilatata.
N. a—Nummulites acutus.
N. be—N. beaumonti.
N. c—N. clipeus.
N. f—N. fichteli.
N. m—N. maculatus.
N. ob.—N. obtusus.
N. pe—N. pengaronensis.
N. pi—N. pinfoldi.
N. s.—N. stamineus.
N. v—N. vredenburgi.
S. r—Spiroclypeus ranjanae.

CE Suite of rocks in Jadva area are unfossiliferous in the main, excepting for its certain members, including the topmost ones, like *Nummulites obtusus* Marlstone, *Assilina* Marlstone and fossiliferous Green Marlstone. For the purpose of the paper, these units are considered as distinct bodies, while other members are lumped together into one. The two overlying suites are highly fossiliferous. The most abundant and important of the fossils are the larger benthic foraminifers. *Assilina, Nummulites, Discocyclina, Alveolina, Heterostegina, Lepidocyclina* are the common genera present. Of these, only *Nummulites* and *Heterostegina* cover the entire upper parts of the stratigraphical sequence of the area and occur in both the WLM and CLMC Suites, though as different species. *Lepidocyclina* is restricted to the CLMC

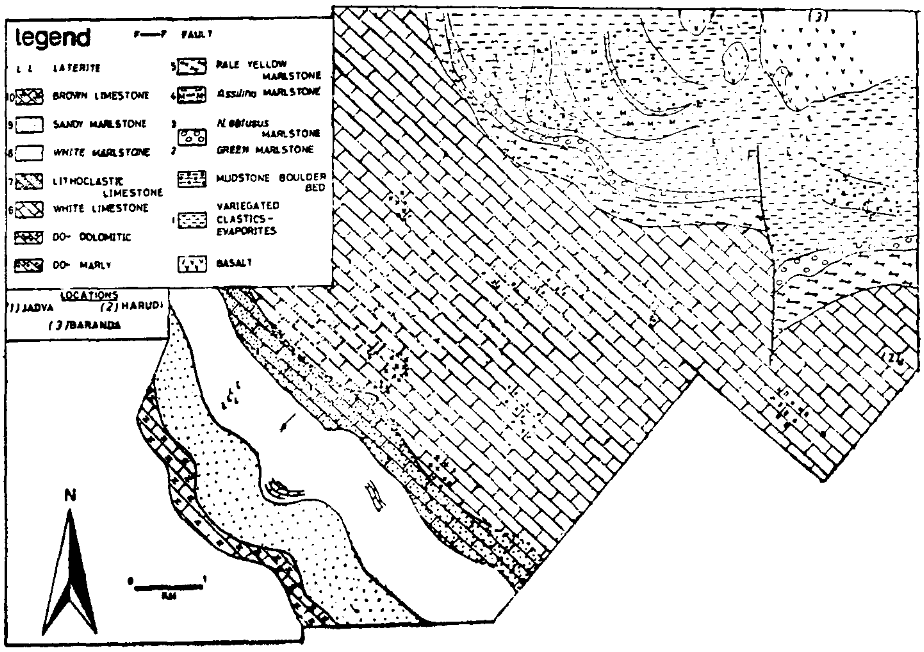

Figure 2: Geological Map of the area around Jadva, western Kutch.

Suite and others to the WLM Suite only.

The above lithological and paleontogical information are included in the Venn diagram with a view to portraying their interrelationship.

METHOD

A stratigraphical unit includes certain lithogical aspects as well as certain paleontological aspects. While quantifying the sttatigraphy of an area, the respective units may be delineated and specified in terms of their areal extent and thickness. In the present context, only areal extents have been considered, since the geological study is based on outcrop studies without subcrop data. Paleontological aspects are considered in terms of relative abundance and distribution of fossils in different litho-units.

A universal set of Paleogene sedimentary rocks represented in the outcrop is first conceived. It is represented in the diagram as the rectangle 'A' with thick outline (Fig. 1). Rectangle 'B' denotes the exposed part of these Paleogene rocks studied in detail ; it is a subset of 'A' and is represented arbitrarily by 180 sq. cm. in the diagram.

In this Venn diagram only the frequencies (i. e. in numerals) of the different sets and/or subsets or elements or their relative proportions, are plotted. Areal extents of different exposed rock-units are calculated from the lithological map (Fig. 2) and are converted to percentages of the total exposed area studied, The rectangle 'B' is, then, divided accordingly into discrete parts, each representing a particular rock-unit as a quantified subset of the total exposed rocks. While dividing the rectangle 'B' and drawing the areas for the different rock-units, the boundary relations between them are also taken into account.

Different species of larger benthic foraminifers that occur as major constituents of the rocks, are represented by circles. Circle diameters are fixed on the abundance of different species judged from field and laboratory studies. The circle may also be considered as conveying an idea about the relative size of the population, since all the genera in question are benthic and stand broadly equivalent chances of fossilisation and preservation. Distribution pattern of the different circles in relation to the areas representing different rock units, indicate the distribution of the fossils in the rock units. It brings out the fossil assemblages of a particular rock unit, as also whether a particular species is restricted to a rock unit or occur in different ones.

Since each species is distinct and different from the other, the circle do not overlap, Intercircle spaces represent other constituents of the rocks, such as, carbonate matrix, clastic grains and other macro and microfossils.

CONCLUSION

The pictorial method described above, can be effectively used for quantitative biostratigraphical as well as facies studies for any sedimentary sequence with necessary modifications.

In the studied area fossils form a major constituent of the rocks. Distribution of the areas of the circles shows approximate distribution of the population of the species of larger benthic foraminifers. Some species, such as *Assilina sp, Nummulites obtusus*, and *Assilina exponens*, are restricted to certain respective particular lithologies, suggesting their facies governed nature, while a larger number of other species show higher degree of tolerance of environmental condition, indicated by their distribution in different litho-units. Such relationships thus may give a pictorial idea of relationships between the litho and the biofacies.

The Green Marlstones at the top of the CE Suite, though persistent and fossiliferous, show divergent character from place to place. At places, it is unfossiliferous or barely so, similar to the other variegated clastics of the CE Suite, while, at others, it is characterised by a biotic affinity with the WLM Suite. The lateral variation is gradual. The Yellow Marlstone, too, appears to be facies variants of the white marly limestone at places. At places it has very sharp contact and at others, a gradational contact. The gradational contacts between different litho-units are shown in the diagram by broken lines. More detailed studies on the interrelationships of different rock units may help to visualise precise ideas on the lithofacies variations.

For quantitative studies, such elaboration on facies relationships is essential. In addition, size of the circles representing abundance of individual species, may be made more precise with a detailed study of species distribution, from a number of close spaced measured vertical sections. Any taphonomic changes in morphology may also be noted and taken into consideration, with a view to recognising the species of these microfossils on a firmer ground.

In the present study stratigraphy of the area is represented by a Venn diagram. By using a series of Venn diagrams for different parts of the basin, a comparative extent of facies variations can also be carried out.

This method can also be used quite effectively in biostratigraphy by fitting time planes in a series of Venn Diagrams erected from vertical columns.

The simple method introduced here, thus may turn out useful in stratigraphical studies.

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