CHAPTER I

I N T R O D U C T I O N

THE REALM OF ICHNOLOGY

Ichnology as expressed by Frey (1975) is the study of all manner of gouges, scraps, and traces made by living or ancient organisms. At the first glance, according to him these oddities might seem to offer little encouragement for serious study. But many looks later, a surprisingly sophisticated body of information begins to emerge, most of it unavailable from any other source.

Ichnofossils that were once dismissed simply as "indirect evidences of ancient life" or "secondary sedimentary structures", now are proving to be invaluable in interpreting many forms of ancient life and the associated sedimentological and environmental conditions.

Ichnofossils (ichno-footprint, track) or trace fossils are tracks, trails, burrows, borings and other structures (e.g. root molds) made by organisms in or on a substrate. Most traces are made post depositionally, although some are contemporaneous with deposition (e.g. escape structures). Trace fossils differ from body fossils in that they are indicative of an organism's behavioural activity in response to substrate

and other paleoecological parameters rather than being part of an organism skeleton. Ichnofossils are preserved in numerous places where body fossils are not, and they document behavioural, ecological, and sedimentological traits that body fossils cannot.

The field of ichnology, in a sense is both old and new. Its basic guiding principles were known to few workers many years ago, and these principles are now being rediscovered by scores of current workers including palaeontologists, stratigraphers, sedimentologists, palaeoecologists, biologists, and others who are adding refinements to the subdiscipline. As Frey (1975, p. IX) rightly puts it, "ichnology is not, a new magic wand", to render sister subdiscipline obsolete, but neither can it be glibly ignored by anyone seriously interested in ancient life or environmental reconstructions".

Ichnology, has developed slowly, and only during the past two decades it has attained worldwide status as a scientific discipline. With a few notable exceptions, most trace fossils were originally interpreted as fossil "algae" or "fucoids". Systematic studies of trace fossils were not initiated until Rudolf Richter's work in the 1920's. Seilacher, (1953) for the first time provided both methodology and satisfactory working classification. Ichnological research was accelerated by Häntzschel (1962, 1965) whose contribution in cataloging trace fossil genera and providing exhaustive

bibliographic data is published as Treatise (Volume 'W', Geological Survey of America - University of Kansas). The development of the last decade, have been concerned mainly with continuous refinement of the discipline.

Like most developing fields, ichnology has its problems. Because the study of traces attracts zoologists, palaeontologists, and sedimentologists, the literature remains scattered through several journals and books. At the present no universal agreement exists on terminology employed in trace fossil work. The problem is still unresolved for many ichnogenera and species. Furthermore, trace fossils like other fossils, generally are inseparable from the rock, and thus they are difficult to collect and curate. As a result, interested geologists are required to go to field and see many trace fossils in a variety of different views, preserved under a variety of different conditions, to build a working expertise on such structures.

PURPOSE AND SCOPE OF INVESTIGATION

The Mesozoic sedimentary sequence in eastern Kutch is thick, widely distributed and relatively well known. It is suited for an integrated paleoecological and paleoenvironmental study especially on the basis of its trace fossil constituents. Despite the fact that many invertebrate species have been

reported from this part of Kutch, virtually nothing has been known about its spectacular suite of trace fossils. Published information on these rocks is further limited to general summaries of lithology, descriptions of mostly incomplete measured sections and incomplete paleoenvironmental interpretations.

The present study is, chiefly based on field investigations conducted during part of each summer from 1980 to 1985 and on the detail study of the trace fossils collected and photographed during that period. Foremost amongst the goals of the field investigations is to gain a complete and detailed knowledge of the sections exposed in the region along with their trace fossil suites and to synthesize its stratigraphical, lithological and paleoecological data gathered from all its exposures. Major objective of the study has also been to revive and update the systematics and nomenclature of the trace fossils, and to obtain accurate geographic and stratigraphical distributional data to describe the mode of occurrence of the taxa.

Finally, it is hoped that this work will provide a framework for future studies in other parts of Kutch were Meoszoic rock sequence is developed and where trace fossils can be located.

OBSERVATIONS AND RECORDING OF ICHNOFOSSILS - TECHNIQUES AND METHODS:

Observations and Recording:

In order to observe, measure and record the ichnofossils effectively the following set of questionnaire was prepared (after Collinson and Thompson, 1982).

The first set (Q. 1) attempts description of the morphology of preservation; the second (Q. 2 & Q. 3) the mode of preservation; and the last group (Q. 4 - Q. 8), the position and process of preservation.

Q. 1 What is the morphology of the trace fossil? Are these identifiable shapes of organisms or part of them?

(a) single shape (e.g. a print or track made by a foot);

(b) several similar shapes repeated to form a pattern (e.g. a track made during locomotion);

(c) a trail (ie. a continuous groove made during locomotion);

(d) a radially symmetrical shape developed in a horizontal plane (e.g. by the resting of a starfish);

(e) a tunnel or shaft caused by a burrower seeking food and/or refuge;

(f) a series of spreiten, which are U-shaped closely related, concentric laminae caused by an animal shifting the location of its burrows as it grows or moves upwards, downwards, forwards and backwards by excavating and back-filling;

(g) a pouch shape, for example caused by the resting of bivalves;

(h) a network pattern.

Q. 2 Is the trace fossil preserved as a cast or mould? Is there evidence that the fill was "passive", i.e. by normal sedimentation, or "active" by for example, the backfilling action of a burrower?

Q. 3 Is the trace fossil preserved as a diagenetic concretion? Chondrites, Rhizocorallium, Thalassinoides and Ophiomorpha are often preserved as calcite and siderite nodules in shales or limonite nodules in sand. Small diameter burrows are often preserved in pyrite which oxidises to red-brown geothite, in flint or chert. These features are often distinguished by burrow margins with different and physical compositions.

Q. 4 Is the trace fossil preserved in an interfacial positions? The top of the casting medium as an epichinial trace, trace like a ridge (positive feature) or a groove (negative feature)? Are there any markers on the top or bottom of the ridges and grooves?

Q. 5 Is the trace fossil preserved in an interfacial position on the bottom of the casting medium as a hypichenial trace, e.g. a ridge or groove? If so, is there any evidences that this was a sediment/water interface? Was the trace fossil preserved at a sediment/sediment interface, possibly between contrasting lithologies, possibly at concealed junction? Are the underlying and overlying laminae deformed?

Q. 6 Is the trace fossil preserved within a bed but outside the main body of the casting medium as an exichnial trace? Here the traces of one lithology (e.g. sandstone) are isolated in a different lithology (e.g. shale).

Q. 7 Is the trace fossil preserved in an internal position with the main body of the casting medium as an endichnial trace? Are the burrows very densely distributed and interpenetrating? If so, the sediment should be referred to as having a bioturbate texture. Are the burrows common but distinct? If so, the term burrow mottling may be more appropriate. Are the structures preserved in full relief? Is the wall of the cast of different composition from the body of the cast; as when a burrow in sand is lined by a layer or layers of mucus and/or faceal pellets made of mud. Does the trace contain internal structures, e.g. spreiten?

Q. 8 Is the trace preserved by burial following erosion, i.e. is it a derived trace fossil? This arises when, after burrowing, erosion takes place and currents winnow away a soft matrix leaving the mucus bound burrow linings as sediment filled "gloves". These can be covered by later, possibly different sediments. Alternatively currents may scour out burrows made in mud and afterwards fill them with sand.

Techniques:

The study of ichnofossils requires one to try to relate fragmentary two dimensional patterns to complex three dimensional records and behaviour left by a diverse range of organisms. A wide range of techniques has been developed. These include acid etching, base etching, sand blasting, staining, serial sectioning, X-ray radiography, infra-red photography; peeling by polyster resin, lacquer, epoxy relief; casting using plaster of paris, silicone rubber, polyster resin etc. Relative merits of each of this techniques depends on the likely problems one has to encountered.

In the present study the author has concentrated on the following cheaper and simpler techniques.

Most of the ichnofossils were photographed in the field. Such samples that could be conveniently be removed were photographed in the laboratory for their finner details. It

should be noted that the photography of trace fossils requires a style slightly different from that adopted with body fossils. Burrows are generally accentuated by wetting the rock surface or by smearing ink over it and then washing it off. Ink smearing produces a stain controlled by differences in porosity. Alizerin Red and Methylene Blue are preferentially adsorbed by clay minerals and thus are useful in dealing with trace fossils in fine-grained sediments. In instances, traces having delicate claw scratches or other fine details whitening by chalk dust and photographing in strong side light advantageously produced good results. Many of the staining techniques normally performed indoors were also applied for the outdoor photography. Spraying carbonate cemented rocks with dilute HCl or Siliceous rocks with KOH was advantageously used to increase relief on fresh facies or rock surfaces.

Methods:

Geological Maps by Wynne and Feeden (1872), Biswas and Deshpande (1970) and Deshpande (1972), were used during preliminary reconnaissance studies. Geological field work was carried out with the help of survey of India Topo sheets No. $41\frac{I}{2+6}$; $41\frac{I}{2+7}$; $41\frac{I}{2+10}$; $41\frac{I}{11}$; and $41\frac{I}{15}$. Stratigraphic sections at important trace fossil localities were prepared and positions of trace fossil occurrence were carefully marked

in the same. During the course of field work the various outcrop patterns their lateral and vertical extents, their major and minor (omission surface) time breaks were also studied. Particular attention was given to the nature of the sedimentary and biogenic structures and these were further photographed. Wherever possible trace fossil samples were collected for laboratory studies and for curating. Various illustrations and diagrams were drawn to show the distribution patterns of trace fossils and their paleoecological significances, and environments of deposition.