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Petrography of sub-surface Tipam Sandstone Formation of a part of Upper Assam Basin, India

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ABSTRACT

The Tipam Sandstone Formation of Miocene age is one of the prolific hydrocarbon producers of the Upper Assam basin, India. In this paper we report on the petrography of the Tipam Sandstone Formation using subsurface samples of two wells of Oil India Limited from Upper Assam. The petrographic study involved preparation of rock thin section slides from conventional core samples and their study under petrological microscope. This study reveals that the sandstones under study are mainly of sublith-arenite, feldspathic greywacke and lithic greywacke types. However, few of them are also of sub-arkose and arkosic arenite types. The sandstones were derived mostly from middle and upper rank metamorphic sources. The tectonic set up of the source area during the time of deposition of the Tipam Sandstone Formation was of quartzose and transitional recycled types.

KEYWORDS: Tipam Sandstone Formation, Petrography, Provenance and Tectonic Setting.

Introduction

Petrographic study of sedimentary rocks enables us to classify the rocks and to understand the environment of deposition, diagenetic history, nature of source rock and tectonic set up of the source area during their deposition. Crook (1974) was the first to propose the method of determining the tectonic setting of sandstones using framework mineral composition, which, since then, has undergone considerable modifications. The main assumption behind sandstone provenance studies is that different tectonic settings contain their own rock types, which when eroded, produce sandstones with specific compositional ranges (e.g., Dickinson and Suczek, 1979; Dickinson et al., 1983; Dickinson, 1985). The Tipam Sandstone Formation of Miocene age is one of the major oil reservoirs of the Upper Assam Basin. The Tipam Sandstone Formation stratigraphically overlies undifferentiated grit beds of the Surma Group in the northeast and the Bokabil Formation in the southwest of Upper Assam Plains and underlies the Girujan Clay Formation of Tipam Group. The formation occurs in the subsurface of Upper Assam Plains and is exposed in the type area of Tipam Hills and different localities of the Naga Hill Ranges. The present study deals with the petrography of subsurface Tipam Sandstone Formation using conventional core samples from two wells- JRN#2 and RGH#5 of Jorajan and Rajgarh oil fields, respectively. The location map of these oil fields has been shown in the Fig. 1.



Fig. 1: Location of the area under study

Geology of the Area

The pioneering work in classifying the Tertiary sediments of this region dates back to 1876. Subsequently, Evans (1932, 1959) classified the Tertiary sequence of Assam, covering the hills bordering Assam Valley, Central Assam and the Surma Valley, into geosynclinal and shelf facies. The generalized stratigraphic succession of Upper Assam shelf zone sediments, after Handique et al. (1989), is as follows-

Epoch	Lithostratigraphic Group	Units/Formation	Thickness (in m)	Major Lithological Types
Recent	-	Alluvium[3]		
Pleistocene	Dihing	Dhekiajuli[3]	1300-2000	Unconsolidated sands with clay and lignite sands
		Unconformity		
Pliocene Miocene	Dupitila	Namsang Beds	0-1000	Poorly consolidated sandstone with clay and lignite sand
		Unconformity		
Miocene	Tipam	Girujan Clay	100-2300	Mottled clay with sandstone lenses
		Tipam Sandstone (Upper)	300-500	Essentially arenaceous sequence
		(Middle)	100-200	Sand/ Shale alteration sequence
		(Lower)	100-200	Arenaceous sequence
	"Surma"[2]	Not subdivided		Sandstone with shale & grit bed
		Unconformity		
Oligocene	Barail	Not subdivided	500-1200	(Upper Part: Mudstone/ shale with sandstone beds and coal bands (Argillaceous sequence) (Lower Part: Sandstone with shale bands (Arenaceous sequence)
Eocene[3]	Jaintia	Kopili alternations	280-500	Splintery shales with sandstone and fine grained sandstone with coal bands
		Sylhet Limestone		
		(Prang Narpuh Lakadong)	350-450 60-170	Splintary shales with sandstone and limestone bands Sandstone, calcareous sandstone and limestone
		Therria		
		Unconformity		
		Precambrian Granitic Basement		

Note:
1. It is difficult to distinguish these two rock units. From regional geologic considerations, an unconformity could however, be inferred between them.
2. Development of the Surma Group which is extensive in the type area of Surma Valley is doubtful in the Upper Assam shelf area.
3. Including Paleocene rocks

Results

Results of the modal analysis of the Tipam sandstones are given in Table 1. The study has shown that the minerals constituting the Tipam sandstones are as follows-

Quartz: - Quartz is the dominant detrital constituent in the sandstones under study. The grains are subrounded as well as subangular. However, few rounded grains have also been observed (Fig. 2a). Both elongate and equdimensional grains are present which show point, long and concavo-convex contacts (Fig. 2b). However few floating grains have also been observed. Percentage of monocrystalline undulose quartz varies from 1.57 to 10.91 and that of non-undulose quartz varies from 16.32 to 43.43. Polycrystalline quartz with '>3 crystal units per grain type' (4.29 to 13.38%) is dominant over '2-3 crystal unit per grain type' (0.00 to 5.65%). Of the polycrystalline quartz with '>3 crystal units per grain type', different types such as stretched metamorphic quartz, schistose quartz, and recrystallized metamorphic quartz are present. Few grains with authigenic growth have also been observed. Clay coat-

ing over some of the grains has been seen due to the presence of argillaceous cement.

A number of chert grains have been observed which are of diagenetic as well as detrital origin.

Feldspar: - Both plagioclase and K-feldspar have been observed. The total

percentage of feldspar varies from 5.85 to 16.53. Displacement of twin lamellae in a few plagioclase grains has been observed (Fig. 2c). A few perthites and myrmekites (Fig. 2d) have also been observed.

Mica: - Micas present in the Tipam sandstone are both muscovite and biotite which are of detrital as well as diagenetic origin. The total percentage of mica varies from 1.77 to 10.04. Alteration of argillaceous cement to muscovite has also been observed. Few of the flakes show bending (Fig. 2e).

Lithic Fragments: - All types of lithic fragments, i.e. metamorphic, igneous and sedimentary, are present. The total percentage varies from 5.39 to 20.13. Metamorphic variety dominates over the other two types.

Cement: - Mainly argillaceous, ferruginous, siliceous and calcite cement have been observed in the studied sandstones. However, in a few of them chalcedony is also present as cementing material in the intergranular spaces along with these cements (Fig. 2f). Total percentage of cement ranges from 1.69 to 26.35. But the argillaceous type dominates over the other types of cement.

Matrix: - Both argillaceous and siliceous matrixes have been observed. Their total percentage varies from 4.61 to 26.15. The argillaceous type is the dominant one.

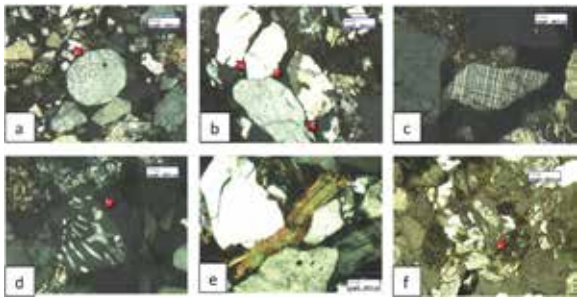

Fig. 2: Representative photomicrograph of Tipam Sandstone Formation: Photomicrograph showing (a) well rounded quartz grain, (b) point and concavo-convex contacts between quartz grains, (c) displacement of twin lamellae in a plagioclase grain, (d) myrmekite, (e) bending of a mica flake and (f) chalcedony occupying intergranular spaces.

Classification

Classification after Dott, 1964 (in Pettijohn, 1984) (Fig. 3) has shown that they are mainly of sublith-arenite, feldspathic greywacke and lithic greywacke types. However, few of them are also of sub-arkose and arkosic arenite types.

Provenance and Tectonic Setting

For determining the types of source rocks of the sandstones under study, the percentages of the different quartz types had been recalculated and plotted in the diamond diagram of Basu et al. (1975) (Fig 4). From this diagram, it has been inferred that the sandstones under study were derived mostly from middle and upper rank metamorphic sources.

According to Dickinson et al. (1983), framework modes of terrigenous sandstones reflect derivation from various types of provenance terrains that depend upon plate tectonic setting. They subdivided triangular QFL and QmFLt compositional diagrams for plotting point counts of sandstones into fields that are characteristic of sandstone suites derived from the different kinds of provenance

terrains controlled by plate tectonics. They developed a method of classifying sandstone suites according to tectonic setting using the subdivided QFL and Q_mFL_t plots. QFL triangular plot has shown that the Tipam sandstones were derived from recycled orogenic source (Fig. 5). From the Q_mFL_t triangular plot, it has been observed that the source areas were mainly transitional recycled, quartzose recycled and mixed types (Fig. 6). However, few of them are also of dissected arc source.

Discussion and Conclusions

From the study of petrography of the sub-surface Tipam sandstones of the two wells, following conclusions can be drawn-

- The Tipam sandstones are mainly of sublith-arenite, feldspathic greywacke and lithic greywacke types. However, few of them are also of sub-arkose and arkosic arenite types. The presence of both arenite and greywacke types of sandstones indicates that the sediments of the Tipam Sandstone Formation were deposited in an environment where there was occasional change in the conditions of deposition.
- Diamond diagram has shown that the sandstones were derived mostly from middle and upper rank metamorphic sources. Some igneous source might also have contributed in the formation of the sandstones under study as is indicated by the presence of myrmekite and chalcedony.
- QFL triangular plot indicates that the Tipam sandstones were derived from recycled orogenic sources. QmFLt triangular plot shows that the Tipam sandstones were mainly of quartzose recycled and transitional recycled origin. The same has also been indicated by the presence of a number of rounded quartz grains.
- The presence of concavo-convex and sutured grain contacts indicates that the Tipam sandstones had undergone mechanical compaction due to the pressure of the overlying strata. However, the compaction was not much intensive during lithification of the sediment as is indicated by the presence of a number of floating framework grains.
- A number of mica flakes show bending. Moreover, displacement of twin lamellae has been observed in a few plagioclase grains. Both of these features indicate influence of tectonic activity in the area under study.

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