Does the Kutch offshore basin record India's Continental breakup history from Africa to Seychelles?

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1. Introduction

The breakup of Gondwanaland led to the creation of many rift basins, of which the Kutch offshore basin is one. Previous geochronological studies of the Kutch onshore rocks have established multiple episodes of magmatism at ~124 Ma, 77-75 Ma and 68-60 Ma. The wells drilled in the Kutch offshore basin encountered magmatic rocks at various depths and stratigraphic levels, but their temporal relationship is not well constrained. In this study we made an attempt to determine the ages of 5 magmatic rock core samples from the Kutch offshore basin using Ar-Ar geochronology and the geodynamic significance of the results is discussed here.

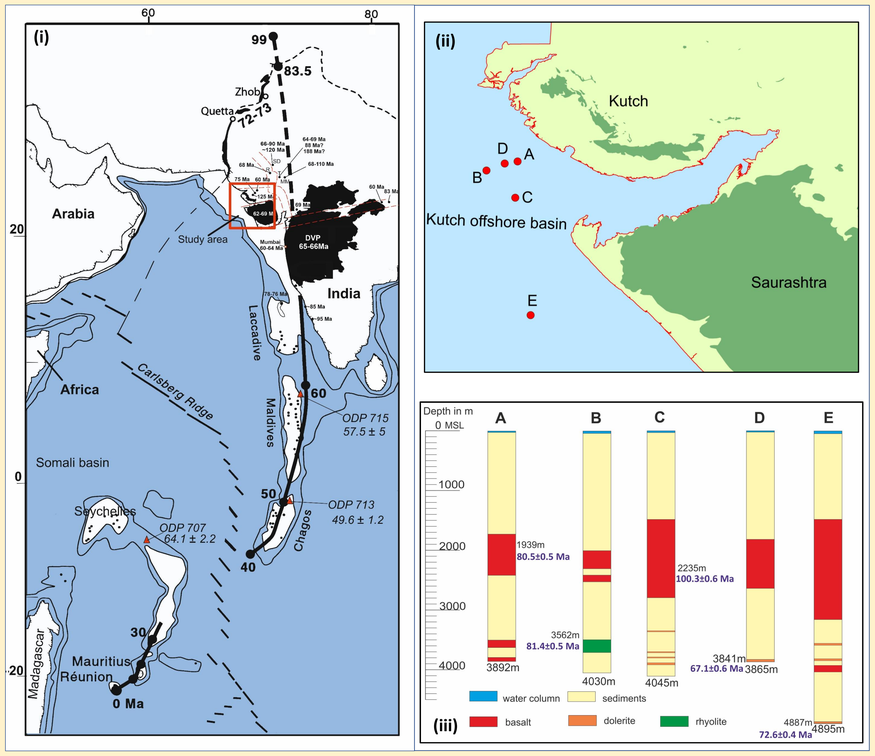

Figure 1: (i) The regional map showing some important features in the Northern Indian Ocean. The red square marks the study area. Volcanics are given in black and the solid black line represents the hypothesized Re-union hotspot track by Mahoney et al., 2002. (ii) The study area map showing the locations of wells in the Kutch offshore basin from which samples were analyzed. (iii) Generalized litho stratigraphic logs of the wells.

2. Motivation and Objectives:

The Kutch offshore basin is a hydrocarbon producing basin and magmatic rocks occur at various stratigraphic levels. Understanding the tectono-magmatic history of this basin will aid in hydrocarbon exploration.

- To understand the tectono-magmatic history of the Kutch offshore basin using Ar-Ar geochronology.

3. Materials and methods

Five magmatic rock core samples from 5 wells (figure 1.ii) were provided by ONGC for Ar-Ar geochronological studies. Using petrography and geochemistry the sample were classified into basalt (b), dolerite (d) and rhyolite (r). The Litho-stratigraphic logs were access from ONGC to understand their stratigraphic position in their respective wells (figure 1.iii).

3.1 Ar-Ar analysis:

Visibly fresh rock chips (~10 g), devoid of secondary minerals were crushed, cleaned in deionized water in an ultrasonic bath, and sieved. About 0.02 g of 220-180 microns' fraction was packed in the aluminum capsules. The Minnesota hornblende reference material (MMhb-1) of age 523.1 ± 2.6 Ma (Renne et al. 1998) and high-purity CaF2 and KSO4 salts were used as monitor samples. After the irradiation, the samples were loaded on the extraction unit of a Thermo-Fisher Scientific noble gas preparation system. Argon was extracted in a series of steps up to 1350°C in an electrically heated ultrahigh vacuum furnace. After purification using Ti-Zr getters, the argon released in each step was measured with a Thermo-Fisher ARGUS VI mass spectrometer located at the National Facility for Ar/Ar Geo-thermochronology in the Department of Earth Sciences, IIT Bombay, India. The plateau age reported comprise a minimum of 45 per cent of the total Ar released and four or more successive degassing steps whose mean ages overlap at the 2σ level excluding the error contribution (0.5 per cent) from the J value. The data were plotted using the program Isoplot/Ex v. 3.75 (Ludwig 2012). The plateau age, isochron age, inverse isochron age and trapped argon compositional ratio are given in the results section. All the errors are calculated for 2σ.

4. Results and discussion

The plateau ages of the samples are 80.5 ± 0.5(b), 81.4 ± 0.5(r), 100.3 ± 0.6(b), 72.6 ± 0.4(d), and 67.1 ± 0.6(d). All samples have atmospheric value for the trapped argon composition within uncertainty limits. The mutually indistinguishable plateau, isochron and inverse isochron ages implying the ages are true crystallization ages.

These ages establish the presence of different phases of magmatism in the Kutch offshore basin ranging from 100-67 Ma. The 100 Ma basalt volcanism from the well C, might represent initial rifting phase before the India- Madagascar break up at 88 Ma. A new phase of bimodal volcanism at ~81 Ma and a ~73 Ma dolerite reported in this study might relate to rifting in the basin between India-Madagascar breakup at 88 Ma and India- Seychelles break up at 62 Ma respectively. Similar phases were also recorded in the onshore 77-75 Ma intrusives of Sadara and Nir Wandh, 83-81 Ma intrusives of Mer Mundwara and 75-72 Ma acidic volcanism in the Sanchor basin represent the continuous extensional setting in NW India.

The undated younger basalts from the wells in the Kutch offshore might relate to ~63-60 Ma intrusives from Dhar Dongar and Saurashtra represent the magmatic record of India-Seychelles break up at ~63 Ma. Similarly, magmatic rocks encountered in the offshore and onshore wells (figure 2) within the Mid Jurassic sediments might have recorded the breakup history of Gondwanaland and opening of Somali Basin. Based on the ages generated in this study along with the published ages and close proximity of this basin to Africa in Jurassic period lead us to infer that the Kutch Offshore might have tectono-magmatic record of the India's Continent break up history of from Africa at 182 Ma? to Seychelles at 63 Ma.

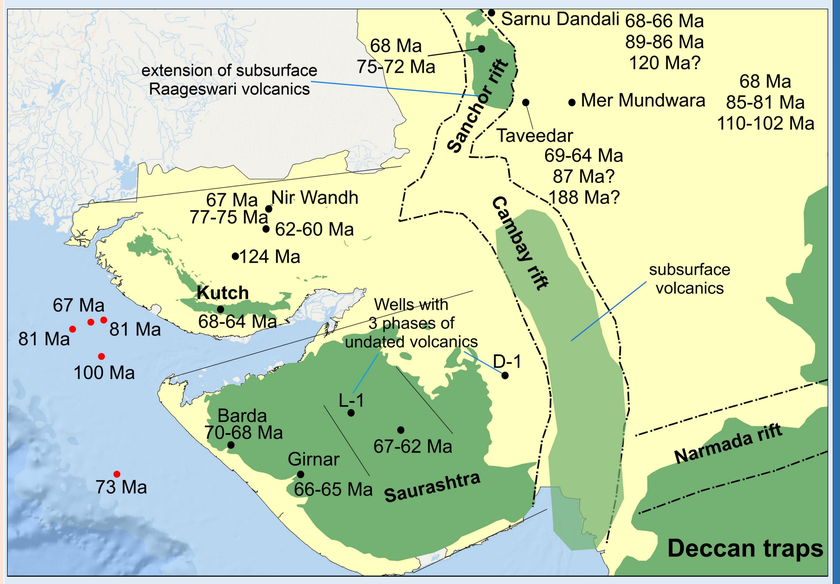

Figure 2: Regional map showing occurrences (surface and subsurface) of magmatic rocks and their age ranges. Red dots are offshore wells.

5. Conclusions and future work

- Different phases of magmatism ranging from 190-60 Ma.
- A new phase of bimodal volcanism in the Kutch offshore at 81 Ma.
- The compilation of ages of magmatic rocks from the NW India show continuous magmatism and extensional setting of this region.
- This range of ages for different magmatic rocks favor a rift related origin rather than a plume/ hotspot model as earlier hypothesized.
- The dating of Mid Jurassic magmatic rocks might give insight into breakup of Gondwanaland.

6. Acknowledgements

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References are given in the supplementary file.