Petroleum System Events in Eastern Part of the Ganga Basin*

Sudhir Kumar Mathur[1], B. N. S. Naidu[1], Subhrashis Adhikari[1], Pinakadhar Mohapatra[1], J. A. P. Clayburn[1], and Stuart D. Burley[1]

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[1]Cairn Energy India Ltd, Gurgaon, India (sudhir.mathur@cairnindia.com)

Abstract

Basin modelling, calibrated with acritarch age dating and integrated with petrographic studies from a new well drilled in the eastern Ganga Basin (Figure 1), has enabled the chronology of the petroleum system events that affected this part of the basin to be evaluated.

New data from the Havidih-1 exploration well indicates that the Karnapur and Tilhar formations (Figure 2) comprise of low porosity, indurated pelites and crystalline limestones respectively. Achritarchs confirm a Late Pre-Cambrian to Early Cambrian age for the Karnapur Formation. An acritarch assemblage comprising several species of leiospheres associated with structured and unstructured organic remains was recovered from the inferred Karnapur Formation. The assemblage includes Archaeodiscina umbonulata Volkova and Archaeodiscina umbonulata (Figure 3), the latter being considered an important early Cambrian zone fossil (Molyneux et al., 1996, Palmer et al., 2001; Brück and Vanguestaine, 2004).

Mineralogical and petrographic studies demonstrate conclusively that the pelites of the Karnapur Formation are characterized by low-grade metamorphic type IIb polytype chlorite (clinochlore, Figure 4) which is indicative of minimum temperatures of 220°C. Achritarchs recovered from the pelites also confirm these sediments have a TAI of 3.5 or higher.

A petroleum system scenario model was made to investigate the implications that the Tilhar Formation succession encountered in the Havidih-1z well had been heated to 220°C. A commercial 1D-basin model (Genesis, proprietary to Zetaware of Houston, Texas) was generated.

The 1D model base case was constructed with a lamalginite Type 1 Tilhar Formation kerogen typical of late Precambrian-early Cambrian organic material (Crick et al., 1988; Jos et al., 2001) and a heat flow model constructed from a tectonic reconstruction of the Ganga Valley basin (Boger et al., 2001; Cawood et al., 2007 and Sarbadhikari et al., 2008) (Figure 5). An indicative Total Organic Carbon (TOC) content of 3% and a hydrogen index of 600 were used in the source rock model. In the base case heat flow model the rifting heat flow maxima is 80 MW/m^2.

The results of the base case simulation indicate that the Precambrian-early Cambrian Karnapur Formation section underwent burial to at least 4.5 km in the Lower Paleozoic with subsequent uplift (Figure 6). The exact timing of the uplift is unknown because the age of the inferred Mesozoic section is poorly constrained. However, the specific timing of the inversion to near surface conditions has little or no effect on the hydrocarbon generation and maturity result. In a slightly higher heat flow scenario case (90MW/m^2 rifting case) burial depth of >5 km was required.

For all geologically reasonable scenarios, hydrocarbon generation begins in the early Ordovician and ceased during the Paleozoic.

Because of the late Paleozoic uplift, structuration may have occurred in the Paleozoic section, although breaching of structures and hydrocarbon migration to surface is a risk element. Further exploration in this part of the basin will require a skill full use of basin modeling and paleo-structural analysis.

Acknowledgement

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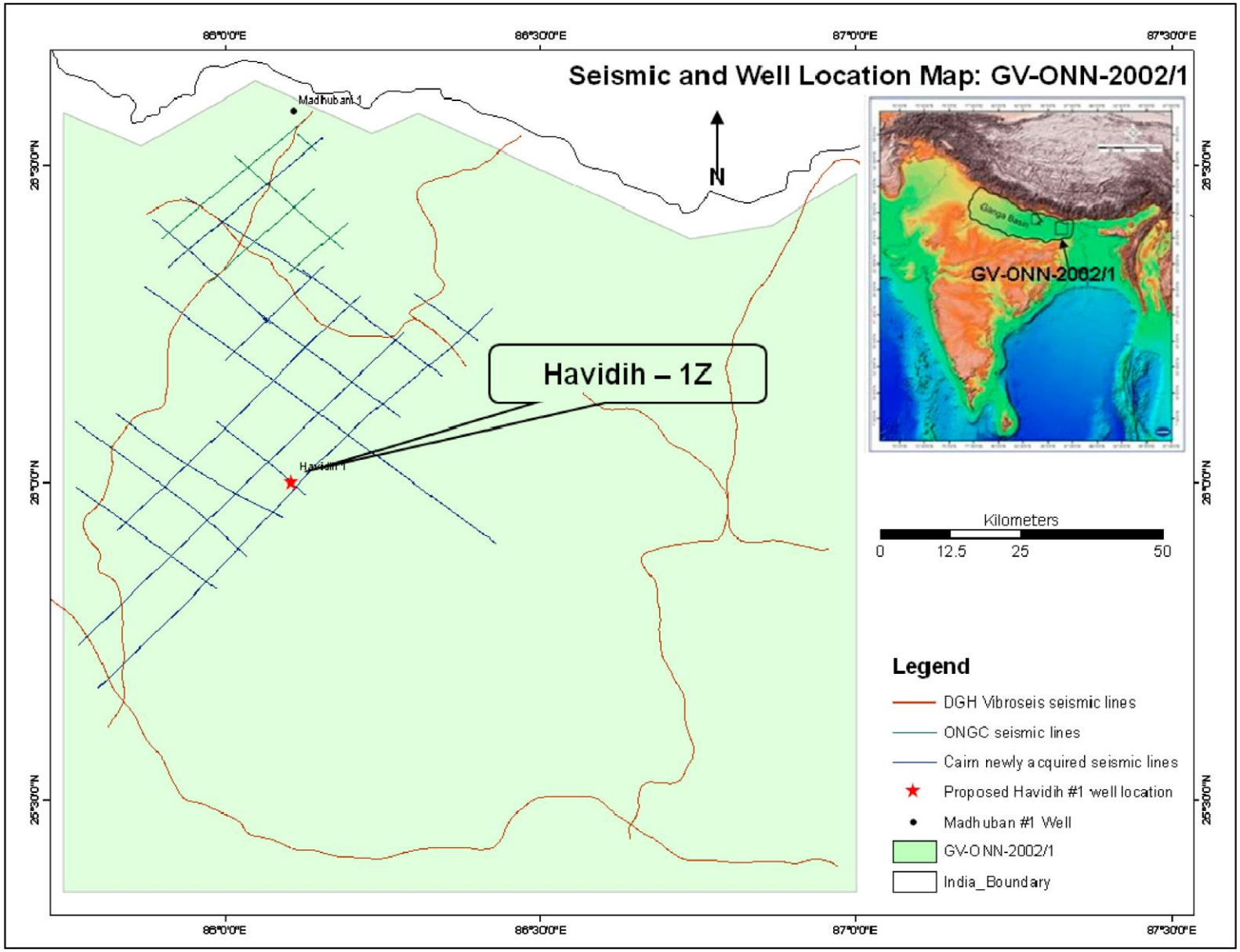

Figure 1. Location map of study area.

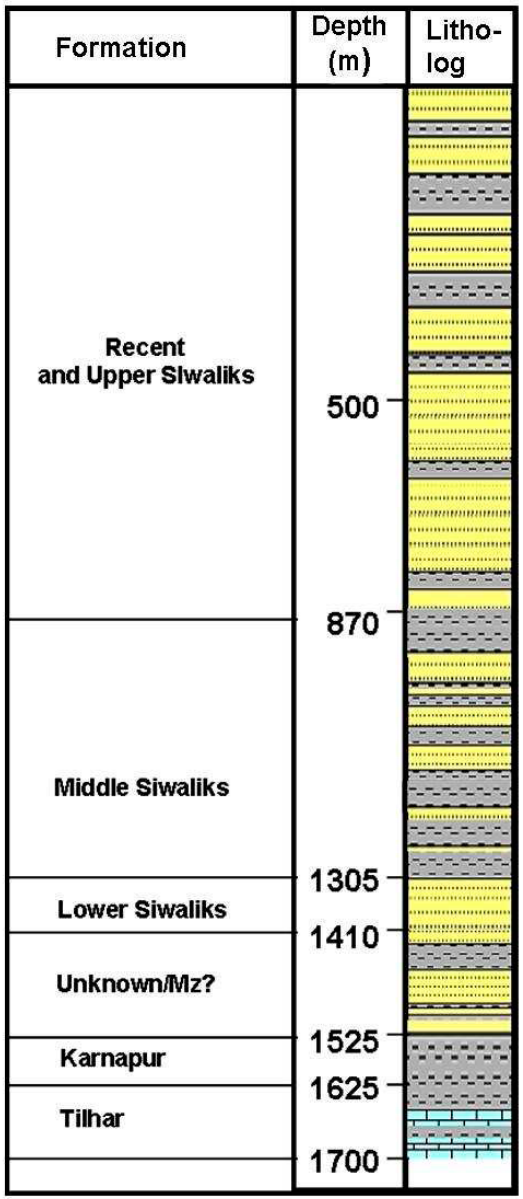

Figure 2. Summary lithostratigraphy of the section encountered in well Havidih-1z well complied from cuttings descriptions and wire line logs.

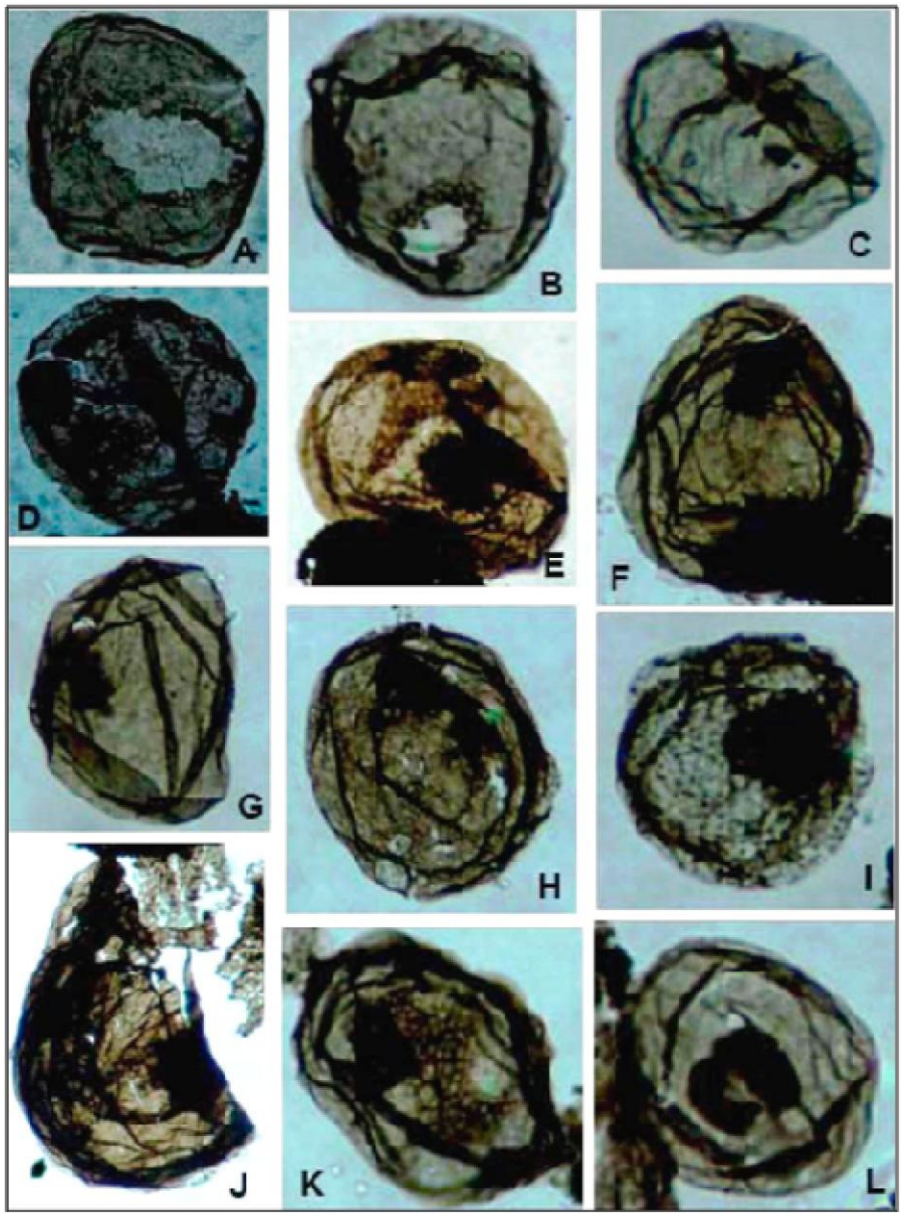

Figure 3. Plane light photomicrographs of the well-preserved acritarchs recovered from the Karnapur Formation of the Havidih-1z well (1,530-1,587 m), including thin-walled leiospheres (A-B) and *Archaeodiscina umbonulata* (DL). These acritarchs are present throughout the Karnapur Formation and are a consistent brown to dark brown colour indicative of a Thermal Alteration Index of 3.5.

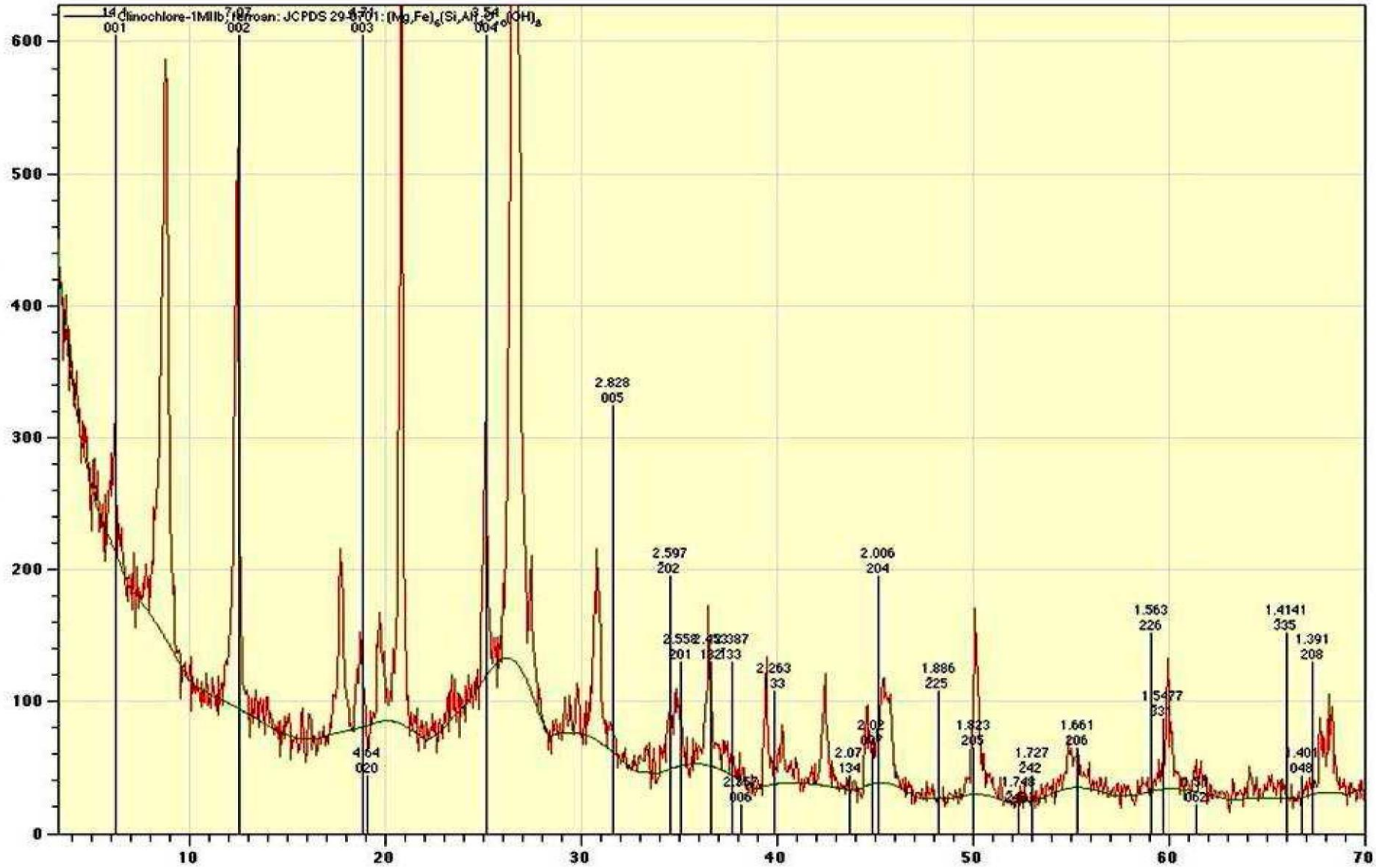

Figure 4. Annotated x-ray diffractogram of the < 2 micron clay fraction from the green pelite sample 1,569 m showing the presence of type IIb clinochlore. Diffractogram scales are diffraction intensity (in counts per second, cps, y scale) and degrees 2 theta (incident-diffraction angle, for Cu K alpha radiation, x-axis). Red diffractogram trace is annotated for hkl diffractions that coincide with lattice spacing for type IIb clinochlore taken from an online mineral reference library.

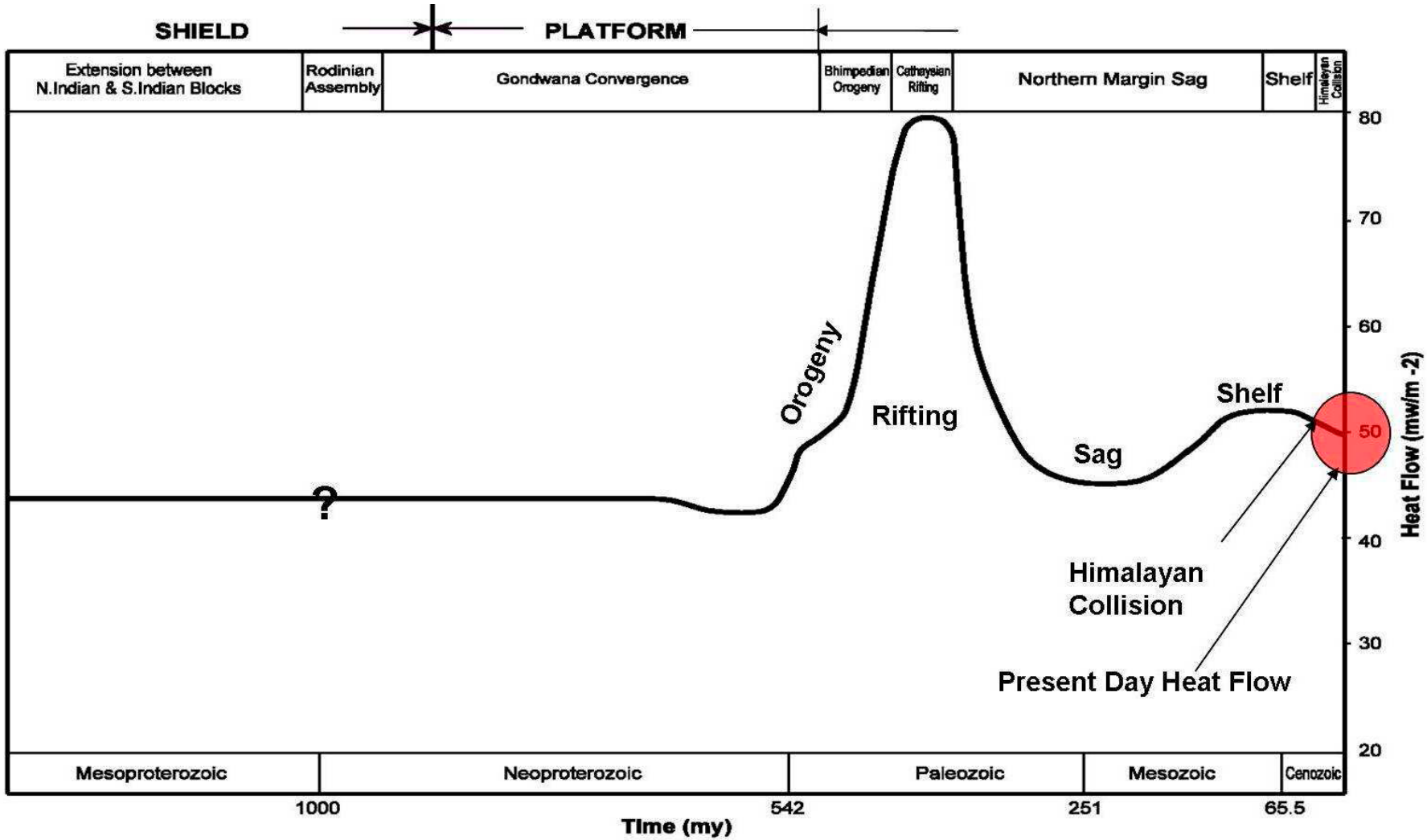

Figure 5. The heat flow model used as input in the base case Genesis 1D basin modeling simulation showing the incorporation of a rifting event during the Cathayasian in which the rifting heat flow has a maximum of 80 MW/m^2. Note the heat flow model is calibrated to present day heat flow measurements (Boger et al., 2001; Cawood et al., 2007 and Sarbadhikari et al., 2008).

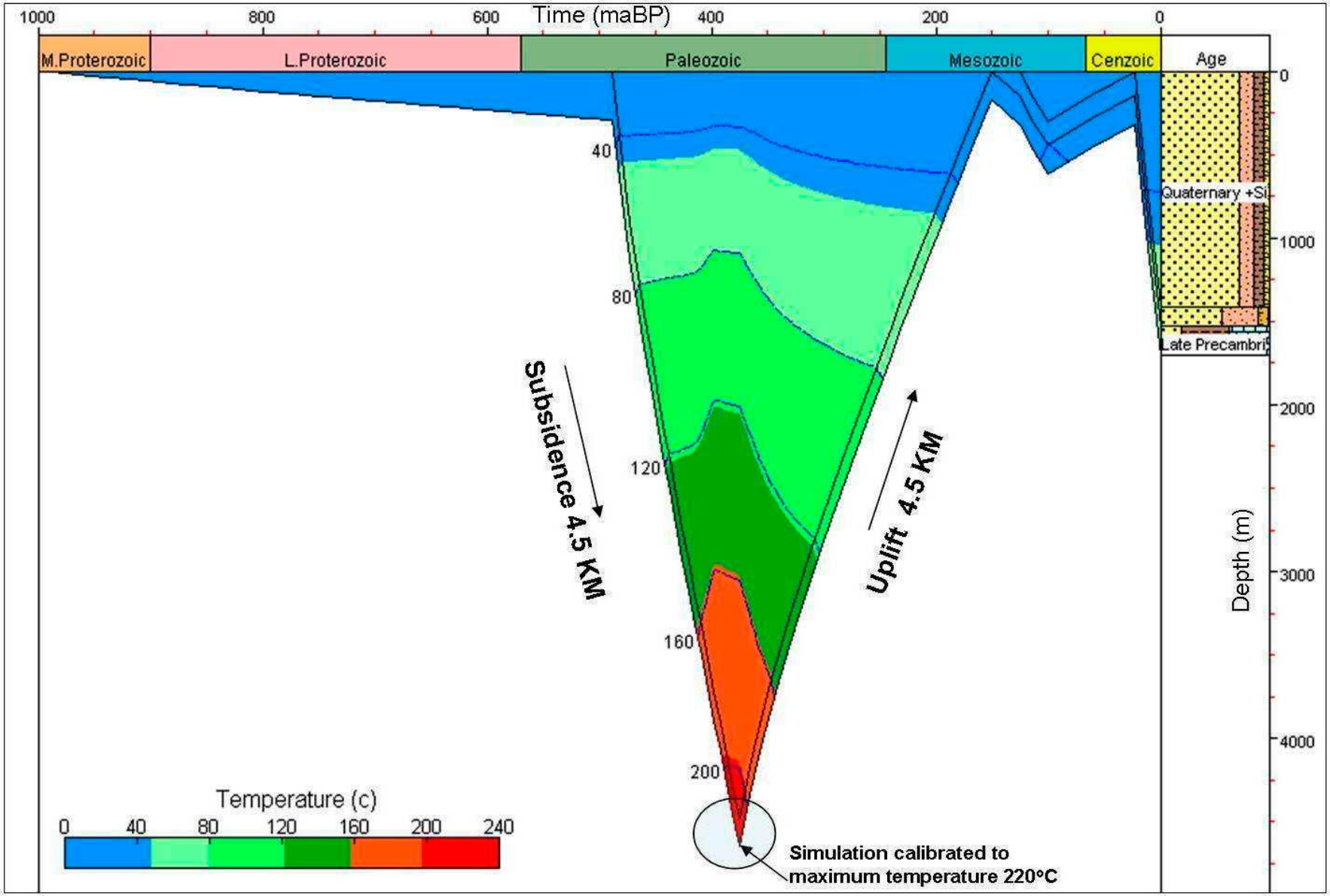

Figure 6. Base case 1-D burial model prediction resultant of minimum temperature of 220°C attained for the Karnapur Formation (indicated by the chlorite and TAI thermal indices) showing the implied 4.5Km depth of burial during the Lower Paleozoic and subsequent uplift prior to 500 m of Mesozoic burial. Model calibrated to present day stratigraphy.