place as recorded off Vengurla[3] (12 m) and Bombay[24] (30 m).

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Effective utilization of geomorphology in uranium exploration: A success story from Meghalaya, northeast India

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The southern fringe of Meghalaya plateau displays a spectacular development of erosional landforms in the thick sedimentary cover of Cretaceous–Tertiary formations. Mahadek formation, the lower member of this sequence, comprises both continental and marginal marine sediments while all the overlying formations are mainly of marine origin. In the study area all the Tertiary formations are eroded away, leaving exposed the continental part of the Mahadek formation, which comprises channel-filled and floodplain sediments. Geomorphologically, both these units express themselves as cuestas but significant textural differences were observed, enabling us to discriminate them in aerial photographs. It is known that the channel-filled sedimentary unit incorporates many favourable geological and geochemical characters to host uranium mineralization. The Domiasiat uranium deposit occurs in this unit only. By virtue of its distinct geomorphology, three domains of channel-filled sediments were demarcated in aerial photographs. Follow-up radiometric field checks on one of these domains, near the confluence of Wah Blei and Kynshiang rivers, have led to the discovery of significant uranium occurrences, opening up promising new avenues for uranium exploration in Meghalaya.

MEGHALAYA plateau is a horst-like feature bounded by Brahmaputra graben, Dawki fault, Yamuna fault and Naga thrust in the north, south, west and east, respectively (Figure 1). The plateau incorporates three major geological provinces[1], viz. (i) the cratonic massif of Archean gneissic rocks, (ii) the Proterozoic Shillong group of metasediments with intrusive mafic rocks and granite batholiths, and (iii) the rift-related basalts and alkaline rocks of late Jurassic to early Cretaceous age and a late Mesozoic to Tertiary sedimentary cover occurring along the southern margin.

The deposition of Cretaceous sediments along the southern fringe of the plateau began with the accumulation of alternate sandstone–conglomerate beds. Con-

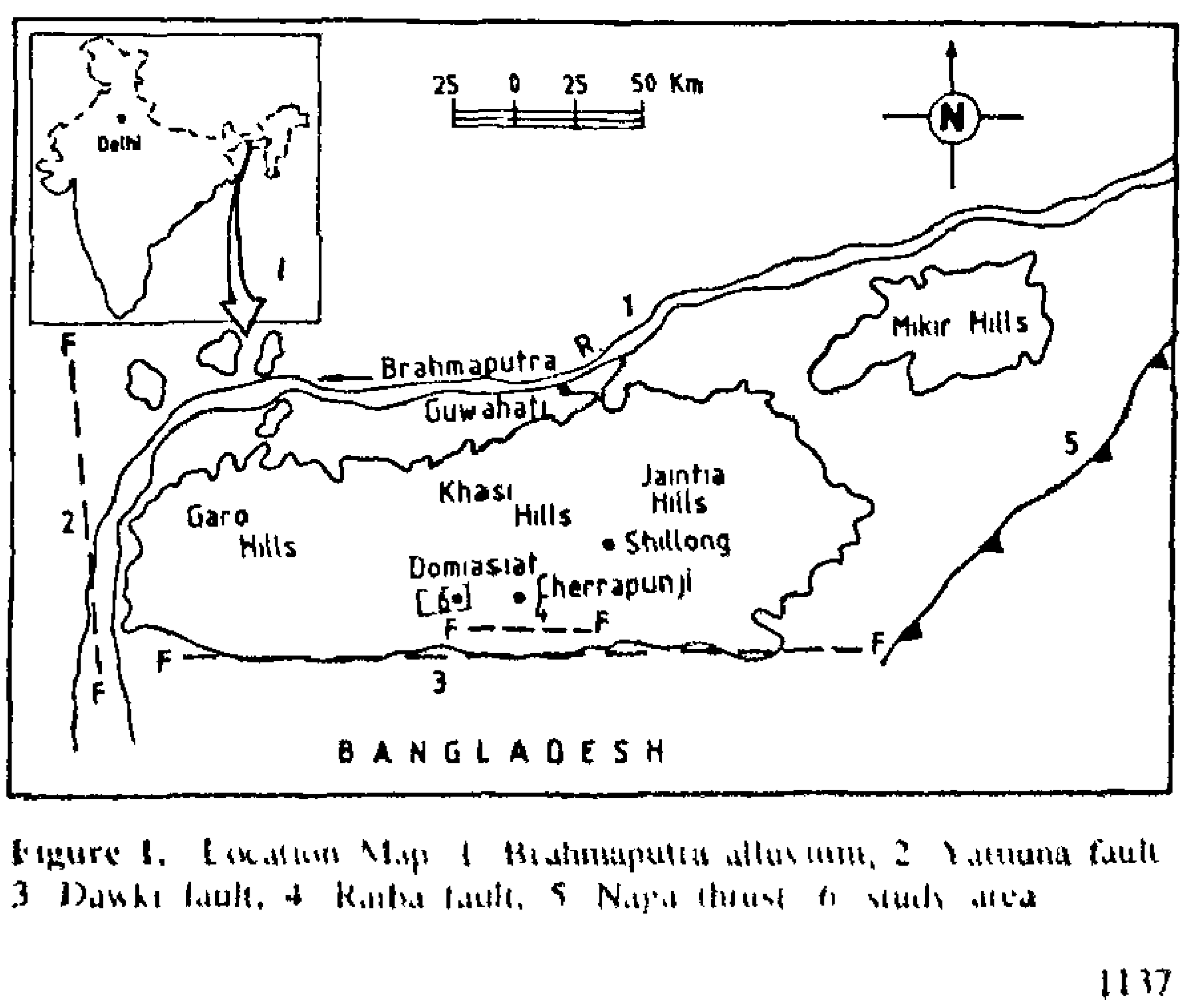

Figure 1. Location Map 1 Brahmaputra alluvium, 2 Yamuna fault 3 Dawki fault, 4 Raba fault, 5 Naga thrust 6 study area

formably overlying these beds in the south and unconformably resting over the Precambrian crystallines in the north is a thick sequence of Mahadek formation, which is characterized by the deposition of both continental and marginal marine sediments.

In the region of present study the vast continental arkosic sandstones are overlain by isolated exposures of marginal marine purple sandstones. Two distinct sedimentary facies, viz. channel-filled and floodplain sediments of the continental unit have been identified. Channel-filled sand stones are flanked on either side by floodplain sediments and both these units were deposited during the upper Cretaceous period along the braided river channels and the corresponding swampy floodplains, respectively. Aerial photographs were extremely useful in accurate delineation of these facies.

Geomorphologically, the southern fringe of the plateau exhibits a spectacular development of fluvial erosional landforms as a result of elevated terrain, flat sediment cover and a huge amount of rainfall. Major landforms in this area include mesas, buttes, escarpments, glens and gorges. The following physiotectonic features have augmented such a marvellous carving of landforms:

1. Cretaceous–Tertiary sediments were deposited over a gentle southerly sloping, roughly flat Precambrian basement.
2. These sediments with the underlying basement were uplifted *en masse* as a horst to more than 1500 m from the level of their original deposition.
3. These sediments did not undergo any structural disturbance after their block upliftment.
4. Due to its unique geographical location, this terrain experiences a humid climate and receives the highest rainfall in the country. The world's wettest places like Mawsynram and Cherrapunji are situated over these sediments only.
5. The resultant gradient due to the block upliftment has triggered intense peneplanation of this area.

Prolonged erosion since Miocene period has resulted in the engraving of the present geomorphology in the southern parts of the plateau.

In the terrain east of Kynshiang river, the region of the present study, most of the Tertiary cover has been removed as sheet wash, exposing the dip surface of the Mahadek sandstone. The remnant uneroded Tertiary sediments stand out as buttes and mesas depending upon the level of erosion they have undergone. The buttes like Lum Kohkhlum, Lum Kuttraw, etc., in this area confirm that the entire terrain was covered by the complete sequence of sediments and that except for Mahadeks almost all the overlying formations have been eroded away by fluvial processes.

As the sediments were having a gentle southwesterly dip slope (5–10°), a characteristic dendritic drainage developed on the sediment surface with a general southwesterly flow which was subsequently superimposed over the basement. Besides, reactivation of basement fractures during the upliftment of the plateau played a role in the southwesterly course of major rivers like Kynshiang, Wah Podhra, Um Sophew, etc., in the area.

South of Kynshiang river, the complete succession of Cretaceous–Tertiary sediments are preserved. Here the Mahadeks sandstones are exposed in the deeper portion of the Kynshiang river. For all practical purposes the sediments exposed south of Kynshiang river are in simple physical continuity with the sediments in the north, excepting that in the north all the sedimentary formations other than Mahadeks have been eroded away.

The channel-filled sandstone facies is characterized by cross-bedding, medium to coarse grain size, frequent variation in grain size both vertically as well as laterally and poor sorting. It incorporates abundant coaly matter as disseminations and stringers along with pyrite. Geomorphologically, this facies expresses itself as cuesta with a gentle southwesterly slope. It occurs as linear patches of upto 10 km long flanked on either side by floodplain sediments and supports a dense vegetation, imparting a dark tone in aerial photographs. In valley sections it has a vertical scarp up to the contact with Precambrian basement rocks. The gentle cuesta slope of this unit is crowded with randomly distributed and smoothly rounded mounds of about 60 m diameter and 10–15 m height, together imparting a custard-apple-skin-like appearance. This geomorphological expression, a characteristic feature of this unit, is the photointerpretation key which has been used to discriminate channel-filled facies from other sedimentary units.

The floodplain sandstone facies is massive in nature, characterized by fine to medium grain size, incorporation of up to 30% pyrite nodules, presence of coaly matter as chunks and well-developed joints. Geomorphologically, this unit also expresses itself as cuesta but does not support good vegetation, with the result a light grey tone and mottled texture is observed in aerial photographs, besides flat, smooth and well-jointed surface. Because of the presence of well-developed joints, a subdendritic to subparallel drainage pattern has been developed on these sediments. The intimate relation of pyrite with this sandstone facies indicates that it was formed in a marshy environment. Such a marshy floodplain favours the thrival of sulphur-reducing bacteria.

The following three linear patches of channel-filled sediments were identified between Kynshiang river in the west and Um Rilang river in the east (Figure 2):

1. A north-south patch of 1–1.5 km in width exposed on the eastern bank of Kynshiang river, north of its confluence with Wah Blei river: This unit continues further south of the confluence and except for a small

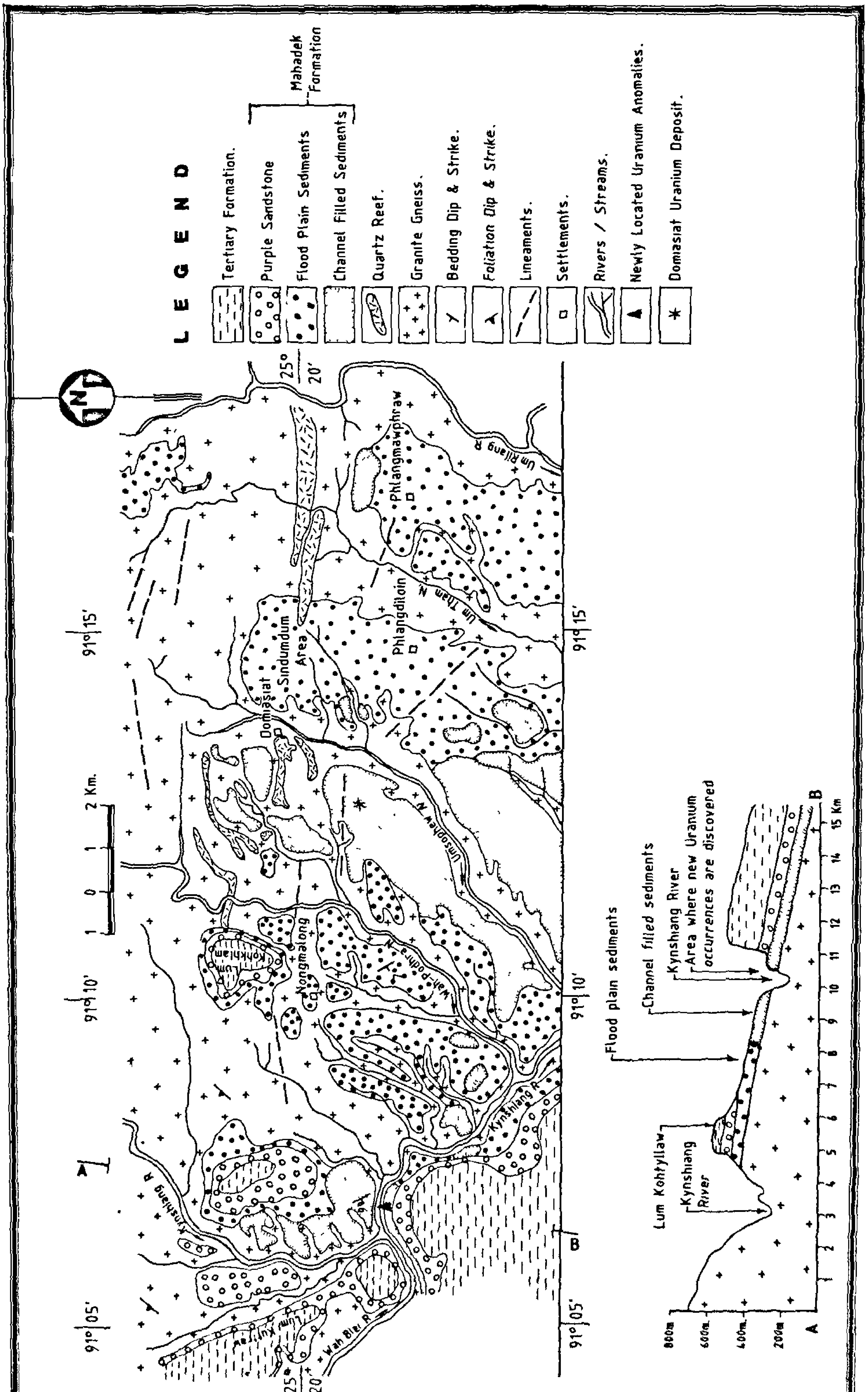

Figure 2. Photogeological map of Nongmalong–Domiasiat–Phlangdiloin–Phlangmawphraw area, W. Khasi Hills, Distt., Meghalaya.

patch of 1.5 × 0.5 km, occurring as a river bench, it is covered by thick sequence of Cretaceous–Tertiary sediments in the south. This channel-filled sandstone is flanked on the west and east by Lum Kuttraw and Nongmalong flood plain sediments, respectively.

2. A north–south patch exposed between Wah Podhra and Um Sophew rivers and south of Phlangdiloin village: The width of this unit is nearly 1 km in the north, which broadens to about 4 km in the south. The Domiasiat uranium deposit is situated on this patch only. This patch of channel-filled sandstone is flanked on the west and east by sediments of Nongmalong and Sindumdum floodplain, respectively.

3. A small patch of 1 × 1.5 km exposed north of Phlangmawphraw and west of Um Rilang valley: Most part of this sedimentary unit appears to have been eroded away, giving way for the formation of Um Rilang valley.

Sandstone-type uranium deposits are epigenetic concentrations of uranium in unmetamorphosed sandstones of fluvial, lacustrine or marginal marine origin. The minimum requirements for the formation of this type uranium deposit are: (1) a provenance rock containing labile uranium, e.g. granite: (2) a transporting medium to carry the oxidized uranium, e.g. ground water; (3) a favourable host rock having the capacity to reduce and retain uranium[2].

By virtue of its higher porosity and permeability, incorporation of disseminated reductants like carbonaceous matter and pyrite, presence of permeability barriers such as siltstones and a score of other factors, the channel-filled sandstone of Mahadek formation is considered to be a good host for uranium mineralization[3]. This is evidenced by a number of uranium occurrences like Domiasiat, Phlangdiloin, Tyrnai, etc. The aim of the present study was to reduce target areas for survey and exploration, which has been successfully achieved by utilizing effectively the geomorphological characteristics to discriminate the channel-filled facies from the others. By the study of aerial photographs and subsequent field checks, a photogeological map has been prepared delineating the three aforementioned channel-filled sedimentary units. Of these, Domiasiat has already been proved to be having a low-grade medium tonnage deposit. In the Phlangmawphraw domain only a small patch of channel-filled sediments are left uneroded after giving way for the Um Rilang valley. Radiometric surveys conducted by scientists of Atomic Minerals Division during the year 1992 have revealed interesting uranium occurrence in this area.

The third patch exposed on the eastern bank of Kynshiang river, north of its confluence with Wah Blei river, which is continuing further south of the confluence had so far remained radiometrically unchecked. During the course of ground truth collection on this channel-filled sedimentary domain in the early months of 1992, the authors have located significant uranium occurrence south of the confluence of Wah Blei and Kynshiang rivers (91°06′34″E–25°18′38″N). These uranium anamolies range from 0.022% to 0.704% of uranium associated with carbonaceous shale, felspathic sandstone and coal band[4]. This newly discovered uranium occurrence in the channel-filled sedimentary domain of Mahadek formation has geared up the uranium exploration activities in this part of the sedimentary basin.

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Monitoring functional property of the transgene through rapid amplification of cDNA ends in *indica* rice transformants

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In plant transformation studies, it is realized that we do not have a handy method to test the functional property of a transgene. In that context, it was considered that utility of the RACE (rapid amplification of cDNA ends) technique is worth testing. The test was conducted through an experiment carried out in *indica* rice cell lines of stable transformants for monitoring the presence of the transcripts of the transferred target genes, viz. *gusA* and *bar*. Based on our success, it was realized that the RACE technique may find its utility in many areas of plant molecular biology studies, besides the one tested.

GENE transfer through transformation has become achievable in most of the plant systems. The methods that are adopted could either be *Agrobacterium*-mediated transformation or any of the direct gene transfer tech-