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Geology and geomorphology of Masol paleonto-archeological site, Late Pliocene, Chandigarh, Siwalik Frontal Range, NW India

Géologie et géomorphologie du site paléonto-archéologique de Masol, Pliocène final, Chandigarh, Siwalik, Nord-Ouest de l'Inde

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ABSTRACT

The Masol paleonto-archeological site is located in the Siwalik Frontal Range in the north of Chandigarh (Punjab, NW India). Many fossils and stone tools can be observed in the colluviums that overlap the present topography constituted by Late Pliocene continental sediments. The Masol paleonto-archeological site is located in the center of a trenched anticline compatible with the direction of plate convergence between India and Eurasia. Erosion processes are very actives and efficient in the area. Around 80 m of vertical erosion occurred in the Patiali Rao valley and regressive erosion incised the Siwalik Hills for ~12 km. At least two levels of fluvial terraces are visible in the Patiali Rao valley and laterally apart the Pichhli River. River bank erosion, gullies, collapses, cavities, regressive erosion, landslides and in situ disaggregation have been observed and are responsible of the significant excavation of the anticline. Substrate composed of sand, sandstone and silt is very erodible in case of heavy rain. Slope destabilizations by seasonal monsoon are responsible of a large part of the colluviums overlapping the present slopes. Some colluviums could be due also to in situ disaggregation of sandstone formations. Due to the very active erosion and to their position on the topography, we believe that these colluviums are very recent.

Mots clés :
Érosion
Terrasse fluviatile
Anticlinal

RÉSUMÉ

Le site paléonto-archéologique de Masol est situé dans les Siwaliks, au nord de Chandigarh, dans le Nord-Ouest de l'Inde. De nombreux fossiles et outils lithiques sont présents dans les colluvions qui recouvrent les formations sédimentaires continentales pliocènes. Le site paléonto-archéologique de Masol se trouve au centre d'un anticlinal dont une partie a été érodée. Les processus d'érosion sont actuellement toujours actifs et très efficaces, sous

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Colluvions
Rivière
Mousson

l'effet conjugué de la mousson et de la faible résistance des roches. Une érosion verticale d'environ 80 m d'épaisseur s'est produite dans la vallée du Patiali Rao et l'érosion régressive a incisé les collines des Siwaliks sur environ 12 km depuis la formation des Siwaliks. Au moins deux niveaux de terrasses fluviatiles sont observables dans la vallée du Patiali Rao et dans le Pichhli choe, l'un de ses affluents. L'érosion des berges, la formation de ravines, les éboulements, la formation de cavités, l'érosion régressive et des glissements de terrain sont responsables de l'excavation de l'anticlinal. Le substrat, composé de sables, de grès et de limons, est très facilement érodé. La déstabilisation des pentes actuelles par les pluies de mousson est responsable d'une large part des colluvions qui recouvrent les pentes dans la zone où se situent les sites paléonto-archéologiques. Certaines colluvions peuvent être également dues à la désagrégation in situ de formations de grès. Comme les processus d'érosion sont très actifs et que les colluvions se trouvent sur les pentes actuelles des collines, il est probable que ces colluvions soient très récentes.

1. Introduction

Frontiers of plate tectonics are of primary interest not only to investigate geological and geomorphological processes due to their present activities but also to observe fossil fauna and archeological tools (King and Bailey, 2006). The Masol archeological site (Chandigarh anticline, Siwalik Frontal Range, NW India) is located in a fascinating geological area undergoing active deformation and significant erosion at the southern limit of the Himalayan mountain range. The area is seismically active and the Siwalik Hills are highly dissected by river erosion in a context of monsoon and tectonic activity. The Masol paleontological and suspected archeological sites have been excavated by erosion from the Patiali Rao valley and the Pichhli choe rivulet. These geological and geomorphological processes allowed us to observe now, the Pliocene fossils and contiguous lithic tools on the surface. Numerous fossils and lithic tools are in the colluviums deposits of the Masol hills. The understanding of these colluviums may help in a better interpretation of the origin of some stone tools and their possible relation with cut marks on bones, slightly oldest than in Africa (Chapon Sao et al., 2015a,b; Dambricourt Malassé, 2015; Dambricourt Malassé et al., 2015a,b; Gaillard et al., 2015; Moigne et al., 2015).

Several studies have described large scale geology and geomorphology of the Siwalik Frontal Range (see section 2). Here, we focus on a smaller area and describe processes as well as phenomena occurring at a smaller scale. The aim of this study is to understand the geological background of the Masol paleonto-archeological site and improve our knowledge about the Masol hills geomorphological evolution. We will (1) describe local deformations observed in the field, (2) describe erosional processes acting on the Masol hills, (3) discuss the rate of erosion and the age of colluviums that overlap the present topography.

2. Geological background

The Himalayan chain has accommodated the convergence between India and Eurasia plates since the Early Paleogene to Eocene (Molnar and Tapponnier, 1975) at rates varying from 44 to 61 mm/year (Minster and Jordan, 1978). Subduction of a highly extended Indian lithosphere within the Himalaya triggered a shortening of approximately 2350 km since 52 Ma (Hinsbergen van et al., 2012). The Main Central Thrust (MCT) marks, on the southern slope of Himalaya, the boundary between Higher/Greater Himalaya to the north (metamorphic series) and Lower/Lesser Himalayan sequences (Kundu et al., 2012) toward the south (epi-metamorphic; Fig. 1). The Main Boundary Thrust (MBT) bound the southern sides of the Lesser Himalaya (medium-grade metamorphic) tectono-stratigraphic zones and the Sub-Himalayan sequences. The Siwalik area (Neogene to Quaternary) is bounded by the Himalayan Frontal Thrust (HFT) at the south. Several large earthquakes occurred along blind structures of northwestern Himalaya (Molnar and Pandey, 1989). A scarp of 10 m of tectonic origin has been observed near Kakron village on the bank of the Budki River (Fig. 2A, southward of the Siwalik Hills) and estimated at ~12 kyr (Singh and Tandon, 2008).

The Siwalik Hills contain sediments of Neogene to Quaternary age. The Siwalik was the locus of sedimentation sourced from the uplifting Lesser Himalaya (Burbank, 1992; Kundu et al., 2012) at a rate that ranges between 0.27 mm/yr to 0.71 mm/yr (Ranga Rao, 1993). Quaternary migration of deformation southward from the MBT to the HFT created active foothill uplift and trapping of Quaternary sediments within intermontane valleys (Delcaillau et al., 2006; Kumar et al., 2001). Non-marine mudstone, shale, sandstone and boulder conglomerate of Siwalik formation has a total accumulation > 6000 m and represent deposition by southerly flowing river systems (Khan and Tewari, 2011; Kumar et al., 2003; Ranjan and Banerjee, 2009). Lower Siwalik formation comprises an upward-coarsening mudrock succession of Miocene age. The Middle Siwalik formation (> 1600 m) is mainly composed of sandstones of Upper Miocene/Early Pliocene ages (Khan and Tewari, 2011; Kumar et al., 2003). Upper Siwalik formation consists of conglomerates, sandstones and mudrocks (Kumar et al., 2003), 2300 m thick (Karunakaran and Ranga Rao, 1976 cited in Delcaillau et al., 2006), of Pliocene to Lower Quaternary age (Delcaillau et al., 2006; Ranga Rao, 1993).

In Northwest India, the width of Siwalik Hills ranges from 10 km to 80 km and they consist of folds and faults that exhibit a large range in shortening (20%–70%) between the MBT and the HFT (Barnes et al., 2011; Powers et al., 1998). We focus on the Chandigarh anticline located between the

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