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Sedimentological study of major paleonto-archaeological localities of the Late Pliocene Quranwala zone, Siwalik Frontal Range, northwestern India

Étude sédimentologique des principales localités paléonto-archéologiques du Pliocène final de la zone Quranwala, chaîne frontale des Siwaliks, Nord-Ouest de l'Inde

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ABSTRACT

Since 2008, the Indo-French research program 'Siwaliks' has been prospecting in the Late Pliocene formations of the Chandigarh anticline in the Northwest of India (Siwalik Frontal Range, Himalayan foothills). More than 200 quartzite tools and 1500 terrestrial vertebrate fossils have been collected from a Pliocene continental formation near the village of Masol. Several fossils show exceptional cut marks. A complete geological investigation of this area was performed in order to reconstruct the paleoenvironment. The geological sequences of the three major paleonto-archeological localities, Masol 1, Masol 6 and Masol 13, were studied. Silt and sandstone samples of the Quranwala fossiliferous area were collected to correlate the stratigraphy among the three localities and to understand the origins of the sediments. Three different techniques were used to analyze the sediments: a granulometric approach, X-ray diffraction and an analysis of heavy minerals. The sediment analysis demonstrates the relationship between the sample collected in Masol and the dismantling of the Higher as well as of the Lesser Himalaya. During the Late Pliocene, Masol was a floodplain with rich continental and freshwater fauna. The rivers were relatively calm, as indicated by the presence of apatite. Despite this, the quasi-simultaneous accumulations of quartzite cobbles and clay, as well as the presence of carcasses of small and large herbivores, suggest sudden climate variations probably due to the monsoon.

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RÉSUMÉ

Depuis 2008, le programme de recherche franco-indien « Siwaliks » prospecte les formations du Pliocène tardif de l'anticlinal de Chandigarh, une petite chaîne du Nord-Ouest de l'Inde, qui s'intègre dans les piémonts de l'Himalaya (la chaîne frontale des Siwaliks). Plus de 200 outils en quartzite et 1500 fossiles de vertébrés d'eau douce et terrestres ont été collectés dans une boutonnière du Pliocène, autour du village de Masol. Quelques fossiles portent des traces exceptionnelles de découpe qui ont retenu l'attention, nécessitant une étude géologique complète de cette zone afin de reconstituer leur paléoenvironnement. Trois principales localités paléonto-archéologiques, Masol 1, Masol 6 et Masol 13, illustrent la séquence géologique de la zone fossilifère, dénommée *Quranwala zone*. Des échantillons de limons et de grès ont été prélevés afin de corréler la stratigraphie entre les trois localités et comprendre l'origine de leurs composants. La granulométrie, la détermination des minéraux argileux (aux rayons X) et des minéraux lourds (par microscopie) montrent qu'ils proviennent du démantèlement des haut et bas Himalaya, d'abord sous forme de blocs et de boues, avant d'être dispersés dans la plaine indo-gangétique qui borde les piémonts par des rivières dont la compétence diminuait vers l'aval. À la fin du Pliocène, Masol était une plaine d'inondation avec une riche faune d'eau douce et terrestre. Les rivières provenant des vallées de l'Himalaya étaient relativement calmes, comme l'indique la présence d'apatite. Néanmoins, les accumulations de galets de roches métamorphiques et de carcasses de petits et grands herbivores suggèrent également la présence de courants importants. Cette présence quasi simultanée de dynamiques fluviatiles énergétiques d'un côté et de conditions calmes de l'autre pourrait correspondre à des variations climatiques rapides attribuables à la mousson.

1. Introduction

Since 2008, an Indo-French program of research has conducted surveys in the hills around the village of Masol (northwestern India). The hills belong to the Siwalik Frontal Range close to the sub-Himalayan foothills (Fig. 1), and constitute a geological inlier (Badam, 1973; Gaur, 1987; Nanda, 1994; Patnaik, 2013), the exhumed oldest part of the Chandigarh anticline core (also called the Masol anticline). The exhumed rocks are rich in fossils known to belong to the Quranwala zone. The fossiliferous Quranwala zone (Sahni and Khan, 1968) is dated to the Late Pliocene (Ranga Rao et al., 1995; Ranga Rao, 1993; Chapon Sao et al., 2016a). From 2008 to 2015, the fieldwork covered an area of 50 hectares, and approximately 1500 vertebrate fossils were collected in 13 paleonto-archeological localities, named Masol 1, Masol 2 and so on, to Masol 13. The result was a collection of stone tools that were found on the surface (various choppers; Gaillard et al., 2016) and, for the first time, rare bones showing exceptional cut marks made by the sharp edge of quartzite cobble fragments (Dambricourt Malassé et al., 2016a,b). The faunal list includes a large number of herbivores, such as *Hexaprotodon* (Hippopotamidae), *Stegodon* (Proboscidean), several genera of bovids and cervids, *Sivatherium* (Giraffidae), rare carnivores (*Hyena*, *Panthera*) and also reptiles such as giant terrestrial turtles (*Colossochelys*) and crocodilians (*Crocodylus*) (Moigne et al., 2016). Very old butchering activity has been demonstrated at the Masol 1 and Masol 13 paleonto-archeological localities, and in the terrace of the Pichhli Choe (a *choe* is a small torrent).

The aim of this sedimentological study is the reconstruction of the paleo-environmental conditions during deposition of the sediments where fossils and stone tools were discovered. We identified clay and heavy minerals, and performed granulometry measurements on several samples. This study is a first approach to understanding the environmental context that prevailed during this period. More precisely this paper contributes to the sedimentological analysis of three major paleonto-archeological localities: Masol 1, Masol 6 and Masol 13.

2. Geological context

The Himalayan range is composed of three units: (i) the Higher Himalaya towards the Tibetan plateau, (ii) the Lesser Himalaya and (iii) the sub-Himalaya or foothills. The Higher Himalaya consists of metamorphic rocks of low and medium pressure (phyllites, quartzites, gneiss with kyanite, gneiss with porphyroblasts, gneiss with psammites, schists with kyanite) and magmatic rocks (granites with tourmaline and granites with biotite) (Singh et al., 2004). Minerals associated with plutonic rocks include blue tourmaline and zircon (Petitjohn, 1975), and minerals associated with metamorphic rocks include staurolite, kyanite, brown tourmaline, epidote and garnet (Singh et al., 2004). The Lesser Himalaya is constituted of metamorphic rocks with an increasing upward metamorphic grade (gneiss with biotite-garnet, schist with sillimanite and kyanite, marble) and intrusions of amphibolites, granites, pegmatites and presence of quartz (Jangpangi et al., 1978; Thakur et al., 1990). The metamorphic conditions allowed the presence (implementation) of the following minerals: hornblende, sillimanite, tourmaline, rutile and apatite (Jangpangi et al., 1978; Thakur et al., 1990).

The Siwalik Frontal Range is 2400 km long, extends from the Potwar Plateau (Pakistan) to North-East India (Assam), and constitutes the south-western border of Himalaya. Its