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Fossil fruit identification by SEM investigations, a tool for palaeoenvironmental reconstruction of Dmanisi site, Georgia

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ABSTRACT

Archaeological excavations and multidisciplinary studies at the site of Dmanisi (Lesser Caucasus, Georgia) have provided an assemblage of lithic artefacts and numerous palaeontological and human remains in a volcano-sedimentary context dating to the early Lower Pleistocene. The sieving of archaeological sediments from Dmanisi also yielded mineralised botanical macro-remains that were analysed according to a particular protocol. The use of scanning electron microscopy (SEM) allowed the comparison between fossil fruit remains and modern specimens, leading to a precise identification of the earlier. Seed remains recognised by this method belonging to several taxa from the Boraginaceae family as well as to the genus *Celtis* L., of the Ulmaceae family. The ecological requirements of these taxa suggest the presence of xeric conditions, a result that is in accordance with data obtained by faunal and stratigraphic studies.

1. Introduction

Archaeologists know since long that botanical macro-remains such as fruits, seeds or charcoals found in archaeological sediments can provide information on past environments. However, seed analysis has mostly focused on assemblages that characterise agro-pastoral activities and plant domestication during the Holocene (van Zeist, 1987, 1988, 1991; van Zeist and de Roller, 1995) and studies of seed and fruit remains from Pleistocene sediments are rare. Such remains are nevertheless attested in some Palaeolithic sites such as Choukoutien Cave (China, Palaeolithic) (Brothwell and Brothwell, 1969; Wang, 2000; Gao, 2004), Mas des caves, Tautavel and Lazaret Caves (France, Middle Palaeolithic) (Pons, 1969; Boone and Renault-Miskovsky, 1979; Bahn, 1984), Douara cave (Syria, Middle Palaeolithic) (Matsutani, 1987), Franchthi cave (Greece, Upper Palaeolithic and Mesolithic) (Hansen, 1980) and Öküzini (Turkey, final Palaeolithic and Epipalaeolithic) (Martinoli, 2002; Martinoli and Jacomet, 2004). Even though botanical macro-remains are less numerous in ancient Pleistocene sites and often fragmented or hard to recognise, they can usually be identified more precisely than most of the pollen grains or phytolith siliceous opals found in the same levels. In general, botanical remains recovered in archaeological layers of this age are rather interpreted in terms of palaeovegetation than as a testimony to human activities.

Significant remains of early Hominids, resembling *Homo habilis* but closely related to the African *H. erectus* (=*H. ergaster*), were discovered in this Caucasian site (Dzaparidze et al., 1989; Gabunia and Vekua, 1993; Gabunia et al., 2002; Vekua et al., 2002; Lordkipanidze et al., 2005, 2007; Rightmire et al., 2006). Radiometric data and faunal assemblages indicate an age of 1.8–1.7 Ma (million years) (Dzaparidze et al., 1989; Gabunia and Vekua, 1995; Gabunia, et al., 2000a), which makes these human remains the most ancient discovered out of Africa. The site is thus of prime interest to our understanding of the diffusion of early Hominids from Africa to Europe at the dawn of the Quaternary. Palaeobotanical investigations in Dmanisi have the potential to provide an ecological frame to these first Eurasian occupations. This paper presents the contribution of the fruit assemblage to the palaeoenvironmental reconstruction at the site with special attention to the methodological protocol used for fossil identification involving in particular the use of scanning electron microscopy.

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2. Geographical, geological and stratigraphical context of Dmanisi

Dmanisi is located in the Mashavera river valley (S–E Georgia), in the Lesser Caucasus, about 85 km southwest of Tbilisi (44°21′E, and 41°19′;N) (Fig. 1). Climatically this region belongs to the south–eastern Caucasus and precipitations are lower than in the West (Volodicheva, 2002). The eastern part of Transcaucasia is not submitted to the high precipitations found in Colchis (West) where the influence of the Black Sea allows the development of subtropical woodlands. The degree of continentality is relatively high and semi-deserts and deserts can occur in eastern Transcaucasia. Contrary to the Colchis lowlands, the Dmanisi region did not constitute a favourable refuge area for relict floras because of its continentality and its isolation by mountain chains. The present vegetation cover around the site is composed of different formations depending on altitudinal gradients. On hilltops, forests of *Fagus orientalis* can sometime appear in humid conditions, but the prevailing ecosystems at the altitude of Dmanisi (1000 m a.s.l.) consist of oak (*Quercus iberica*) and oak-hornbeam (*Quercus iberica*, *Carpinus caucasica* and *Carpinus orientalis*) forests.

A calcareous cretaceous substratum occurs in the Dmanisi area. Basalt flows, ashes, lacustrine and alluvial deposits that successively came into being at the beginning of Pleistocene can be observed in many places. The Pleistocene fossiliferous site was discovered on the top of a promontory standing approximately 80 m above the present-day confluence of two rivers: the Masavera River to the West and the Pinezaouri River to the East. Palaeoanthropological and palaeontological remains were discovered in volcanoclastic and alluvial sediments, directly overlying the basalt flows (Dzaparidze et al., 1989).

The basaltic lava has a normal magnetisation and is correlated with the Olduvai geomagnetic subchron, ranging between 1.95 and 1.77 Ma (Gabunia et al., 2000a; Garcia, 2004). An age close to 1.85 Ma was attributed to this basaltic substratum by radiometric $^{40}Ar/^{39}Ar$ and K/Ar methods (Maisuradze et al., 1989; Schmincke and van den Bogaard, 1995; Gabunia et al., 2000a).

The Dmanisi sequence (Fig. 2) is divided into two major stratigraphic units: A and B (Gabunia et al., 2000a, 2002). Stratum A is composed of different layers of ashfalls. The lowest layer (A1) consists of black sandy ashes. The upper A layers are characterised by weak pedogenic features. Stratum B deposits include ashfalls, as well as a complex of deposits (Fig. 2) that filled pipes and gullies that had formed along collapsed pipes (Lordkipanidze et al., 2007). Many lithic artefacts and bones were excavated from stratum B and human remains were especially found associated with fauna in units B1z, B1x and B1y (Fig. 2). Almost all over the site, deposits are cut through by diagenetic carbonate linings, ca. 30 cm thick, probably caused by groundwater circulation. The excellent preservation of fauna, human remains and fossil fruits are probably due to the formation of this limestone crust. The deposition process of the entire sequence seems to have occurred during a short interval after the volcanic eruption (Mallol, 2004).

Palaeomagnetic studies present a normal polarity for the basalt and the overlying ashes from stratum A and a reverse polarity for stratum B (Gabunia et al., 2000a; Lordkipanidze et al., 2007). The first ash layer A1 is dated to 1.81 ± 0.05 Ma by the $^{40}Ar/^{39}Ar$ radiometric method (Lumley de et al., 2002). According to this set of data, stratum A from Dmanisi is contemporaneous with the Olduvai event. However, stratum B of reverse polarity can be considered as posterior to the Olduvai episode. Fossiliferous remains and lithic artefacts recovered in these deposits are thus related to the beginning of Matuyama period (Gabunia et al., 2000a, 2002; Rightmire et al., 2006; Lordkipanidze et al., 2007). Electron spin resonance (ESR) dating of dental remains confirms this geochronologic hypothesis in the early Pleistocene (Garcia, 2004).

These data are also supported by biostratigraphy based on mammal and micro-mammal assemblages correlated to the end of Pliocene or the beginning of Early Pleistocene (Dzaparidze et al., 1989; Gabunia and Vekua, 1995; Gabunia et al., 2000a).

3. Materials and methods

3.1. Sampling and field collection

All material presented in this paper was collected during excavations taking place at Dmanisi from 2000 to 2004. Fruit remains

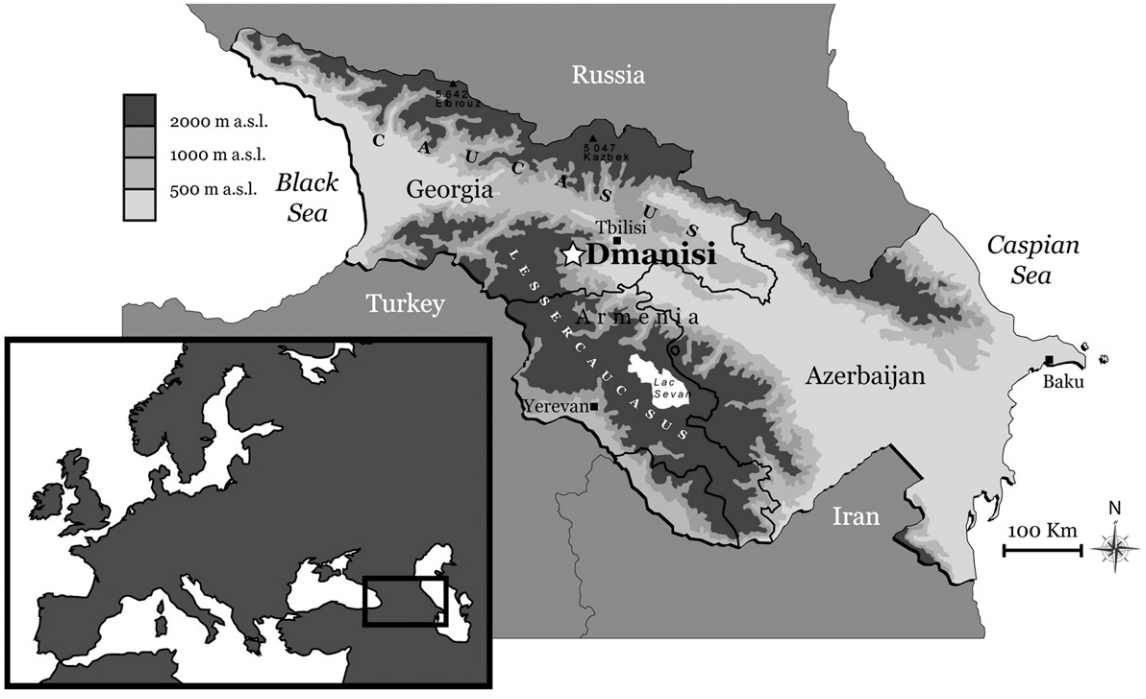

Fig. 1. Location of Dmanisi site in Georgia.