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Holocene palynology and palaeoenvironments in the Savanna Biome at Tswaing Crater, central South Africa

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ABSTRACT

A radiocarbon dated pollen and microscopic charred particle record from the Holocene section of the Tswaing Crater in the Savanna Biome of South Africa give new evidence for environmental changes during the period c. 9400–1800 cal years BP. Pollen grains are scarce or absent in layers dating from before 9400 cal years BP but deposits rich in pollen occur in overlying layers. The section dated between 9400 cal years BP and c. 7200 cal years BP contains grass, Asteraceae and dry savanna pollen types that suggest fluctuating but generally dry moisture conditions. Later between c. 7200 and 1800 cal years BP, broad leaved savanna woodland elements and local swamp pollen indicate relatively stable vegetation and wetter mildly fluctuating climatic conditions, which is consistent with previously published biomarker analysis. Between c. 6200 and 5500 cal years BP, the numbers of charred particles increased slightly. This indicates burning activity, which can probably be attributed to dry season ignition of denser fuel under relatively moist conditions. A decrease of local swamp pollen between c. 3600 and 3500 cal years BP suggests that conditions became briefly drier again as pollen of woody elements declined in favour of open grassland pollen. A comparison between the Tswaing pollen profile and various other sequences within the central interior of South Africa suggests generally similar conditions over the central interior of the sub-continent during the Holocene deviating from sequences further afield along the coastal areas of southern Africa. Between 9400 cal years BP and ca. 7200 cal years BP, the western and southern coasts were probably controlled by different atmospheric and oceanic circulation regimes under the influence of a strong westerly winter–rain system while the north-eastern area where, Tswaing is situated, experienced weaker precession and less summer rain from the Intertropical Convergence Zone.

1. Introduction

For the understanding of the development of the Southern Hemisphere's climate history it is crucial to monitor developments in the different continents including southern Africa during the Holocene. Chase et al. (2009, 2010) proposed that Northern Hemisphere forcing influenced the sub-continent of Southern Africa based on isotope studies in the Namib Desert region and regional data from marine and terrestrial archives. The results indicate early Holocene moist conditions and subsequent progressive aridification that follows the pattern of the African Humid Period (AHP) of c. 14,800 to 5500 cal. yr BP (Kutzbach, 1981; Kutzbach and Street-Perrott, 1985; Street-Perrott and Perrott, 1993; deMenocal et al., 2000). This view is in conflict with general conclusions based on pollen from the thermal spring locality Wonderkrater and a previous study at Tswaing Crater impact crater (Scott, 1999a,b) and other sites (Fig. 1), which propose that Southern Hemisphere precessional forcing during the Holocene played a role in controlling climate fluctuations and modifying the vegetation in the region (Scott, 1993; Street-Perrott and Perrott, 1993; Partridge et al., 1997; Scott, 1999a,b; Scott et al., 2008; Brook et al., 2010). Truc et al. (2013) re-investigated the Wonderkrater pollen data and propose a different interpretation for the Holocene emphasising a link between conditions in the Savanna Biome of South Africa and sea surface temperatures in the Indian Ocean and suggesting that this relationship supersedes the influence of latitudinal shifts in the ITCZ.

These interpretations should be considered in view of the complexity of the different proxy data (Burrough and Thomas, 2013) in the central savanna region and in view of the scarcity of available pollen sequences. Complicating our understanding of Holocene palaeoenvironments further, is that the most often quoted source of proxy evidence, viz., isotope data from the Cold Air Cave in the

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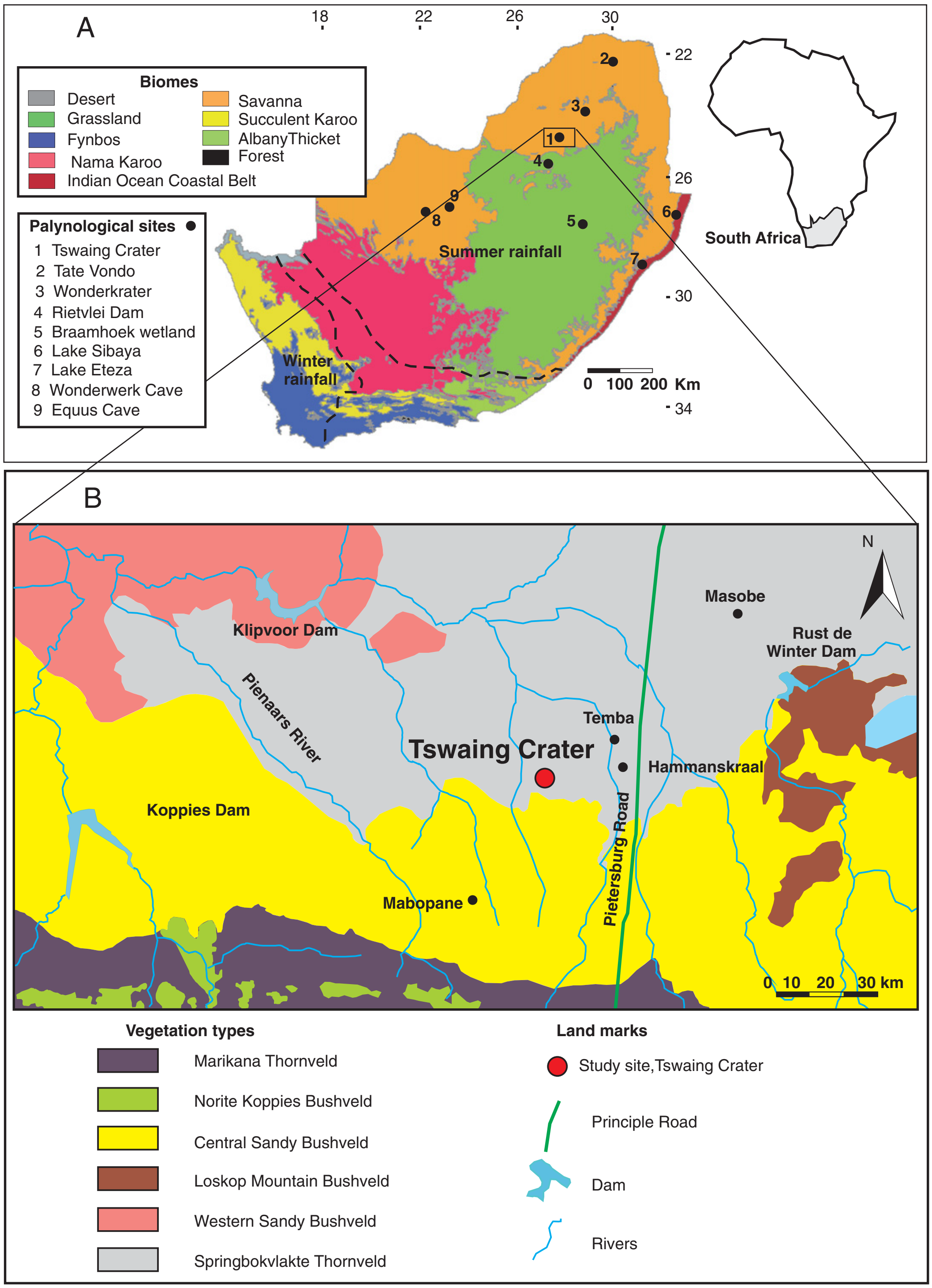

Fig. 1. Locality maps showing biomes, boundaries of summer and winter rainfall areas on the right and left sides of the dashed lines and localities of some palynological sites (dots) (A), and a detailed vegetation map of the Tswaing area (after Mucina and Rutherford, 2006) (B).

Makapansgat Valley (c. 150 km to the north of Tswaing Crater) (Fig. 1) (Holmgren et al., 1995; Holmgren et al., 2003), have been interpreted in various ways by different authors (Brook et al., 2010; Chase et al., 2010; Sletten et al., 2013). Therefore we revisit the previously studied Tswaing Crater site (Scott, 1999a,b) with the aim of improving the chronology and resolution of pollen data in a new core (Tswaing II) and to shed new light on the moisture development in the region. The results are observed in conjunction with geochemical results presented by Kristen et al. (2010) and then compared with those of several other sites in the summer rainfall region of southern Africa (Scott, 1982a; Norström et al., 2009; Neumann et al., 2010; Scott et al., 2012) from the Savanna Biome, the Grassland and Indian Ocean Coastal Belt Biomes (Rutherford and Westfall, 1986; Mucina and Rutherford, 2006). Because vegetation development in the central savanna region is thought to be under the influence of moisture from the Indian Ocean (Bard et al., 1997; Sonzogni et al., 1998), sea surface temperatures are also considered in order to improve our understanding of climate change in the region.

The lake deposits in the Tswaing Crater were drilled by Partridge et al. (1997, 1993) and a palynological study on the core, which we now