Available online at www.sciencedirect.com
ScienceDirect
Sedimentary Geology 193 (2007) 47–58
Sedimentary Geology
www.elsevier.com/locate/sedgeo

# Englacial kames near Jeziorany (Warmia — western Masurian Lakeland, Poland): Morphology, internal structure and origin

Wojciech Morawski *

*Polish Geological Institute, ul. Rakowiecka 4, 00-975 Warszawa, Poland*

**Abstract**

Groups of hills on a regional Vistulian (Weichselian) deglaciation plateau (Warmia, NE Poland) are covered by till of up to a dozen metres thick. It is the same till of the main stadial of the Vistulian glaciation that outcrops in the upland. The internal parts of the hills consist of fine-grained sands. These glacial landforms are referred to as englacial kames; they result from infilling of englacial caverns with sand. The orientation of the kame fields and the form pattern within these fields coincide with the system of primary crevasses in the ice, as it was reconstructed on the basis of the orientation of postglacial crevasse forms. The origin of the englacial caverns at crossing points of crevasse surfaces in the glacier is discussed. Structural analysis (relationship with a circular lineament, local differentiation of the complete profile of the Pleistocene deposits, possibility of occurrence of faults — festoon glacitectonics) suggests that the origin of these landforms is related to movements in the substratum.


*Keywords:* Glacial landforms; Englacial processes; Kames; Warmia; Masurian Lakeland; Vistulian

## 1. Introduction

Kames belong to the most common glacial landforms in the Polish Lowlands. A number of classifications for kames as landforms have been presented (Flint, 1947; Bartkowski, 1954, 1963; Szupryczyñski, 1965; Baraniecka, 1969; Flint, 1971; Price, 1973; Klimaszewski, 1978; Klajnert, 1984; Brodzikowski and Van Loon, 1987, 1991; Brodzikowski, 1993; Huddart and Bennett, 1997; Benn and Evans, 1998). However, the wide variety of kames causes that many hypotheses concerning their formation remain controversial (e.g. Benn and Evans, 1998).

The opinion of the present author is that only essentially rather isometric glacial landforms formed as a result of deglaciation, and composed mainly of fine-grained sand and silt should be interpreted as kames. The underlying reasoning is that these landforms originated as supraglacial glaciolacustrine sediment concentrations deposited in holes on the ice (closed basins) and in between dead-ice blocks, during deglaciation (Boulton, 1971, 1972; Klatkowa, 1972; Shaw, 1972; Schwan et al., 1980; Błaszkiewicz, 1988). Thus, this term refers to the classical glaciolacustrine kames (accumulated in holes on the ice) that were considered by Baraniecka (1969) to be kames *sensu stricto*.

The present author suggests also that linear landforms (ridges), in particular those composed of coarse-grained material (sands, pebbles, cobbles, boulders) deposited subaerally in open ice crevasses as a result of the dynamic flow of meltwater (the "longitudinal kame bars" of Baraniecka, 1969; and the "crevasse kames" of Klimaszewski, 1978), should not be considered as

* Tel.: +48 22 8495351x378; fax: +48 22 8495342.
*E-mail address:* wojciech.morawski@pgi.gov.pl.

0037-0738/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.sedgeo.2005.10.011

kames. Such landforms should be sedimentologically classified as "crevasse fillings" (Flint, 1928, 1947; Brodzikowski and Van Loon, 1991; Dreimanis, 1995). Glacial landforms that are composed of ice-contact deposits – flow till, and glaciofluvial sediments, frequently with lenses and/or partial flow till cover (the "kame moraines" of Charlesworth, 1957) – should be called dead-ice moraines, following Niewiarowski (1961).

Even a highly experienced earth scientist faces atypical landforms, the origin of which cannot be identified without detailed examination. The present contribution focuses on such atypical accumulation landforms, which are located near Jeziorany, Warmia (western Masurian Lakeland). In the present author's opinion they represent "englacial kames".

## 2. Study area and research methods

The study area is located in Warmia, the western part of the Masurian Lakeland, northern Poland (Fig. 1). It is a deglaciation plateau with various well preserved

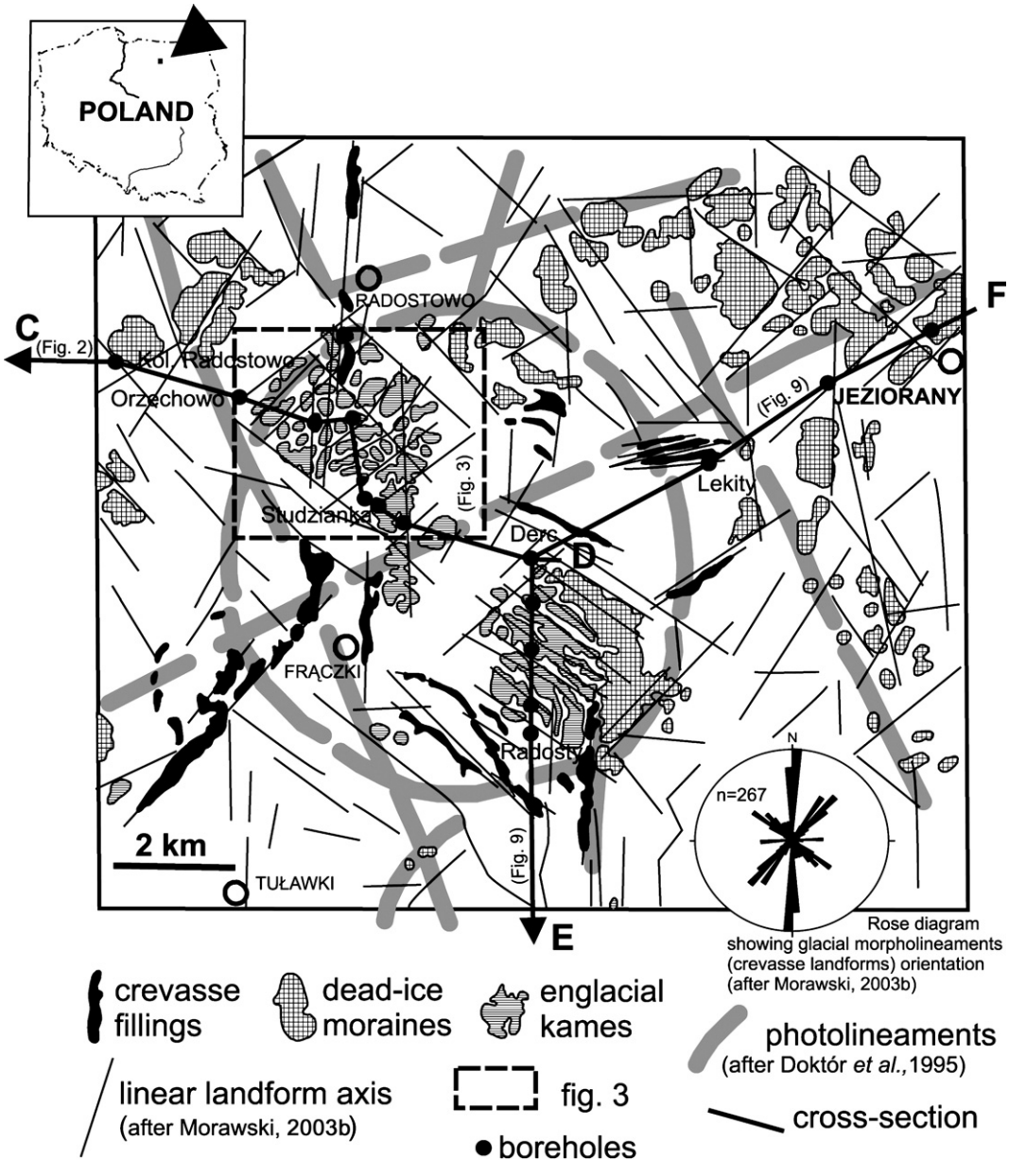


Fig. 1. Englacial kame fields and orientation of the glacial morpholineaments of the Jeziorany region.