Geoscience Frontiers 4 (2013) 449–468

Contents lists available at SciVerse ScienceDirect

China University of Geosciences (Beijing)

Geoscience Frontiers

journal homepage: www.elsevier.com/locate/gsf

Research paper

Geochemistry of fine-grained sediments of the upper Cretaceous to Paleogene Gosau Group (Austria, Slovakia): Implications for paleoenvironmental and provenance studies

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ARTICLE INFO

Article history:
Received 24 May 2012
Received in revised form
30 October 2012
Accepted 30 November 2012
Available online 28 December 2012

Keywords:
Gosau Group
Geochemistry
Pre-Neogene Vienna Basin
Boron
Factor analysis
Provenance

ABSTRACT

Bulk rock geochemistry of 169 fine-grained sediment samples of the upper Cretaceous to Paleogene Gosau Group (Northern Calcareous Alps, Austria and Slovakia) from borehole and outcrop localities was performed to separate non-marine and marine deposits. Geochemical characteristics of different Gosau depositional systems, basins and sediment provenance using major-, trace-, and rare earth elements were also investigated. Geochemical proxies such as boron concentrations were tested for seeking the possibilities of paleosalinity indicators. Due to the fact that several pelagic sections are represented by extremely low boron contents, B/Al* ratios are recognized as more robust and differentiate reliably between marine (mean: 160 ± 34) and non-marine (mean: 133 ± 33) samples. Using statistical factor analysis, hemipelagic to pelagic samples from the Gießhübl Syncline and Slovakian equivalents can be differentiated from marginal-marine to non-marine samples from the Grünbach and Glinzendorf Syncline related to terrigenous (SiO_2, Al_2O_3, K_2O, Th, Rb, Zr and others) and pelagic indicative elements (CaO, Sr, TOT/C and B/Al*). A clear indication for ophiolitic provenance is traced by high amounts of chromium and nickel. Only non-marine successions of the Glinzendorf Syncline show higher Cr and Ni concentrations (up to 250 and 400 ppm, respectively) and enriched Cr/V and Y/Ni ratios trending to an ultramafic source.

1. Introduction

Fine-clastic, shaly to marly sediments may be preferentially used to identify overall changes in sediment source areas and depositional conditions such as limnic versus marine, because they normally cover a longer and more continuous time period compared to coarser-grained sediments such as sands and conglomerates (e.g. McLennan et al., 1993; Hofmann et al., 2001; Pearce et al., 2005; Rahman and Suzuki, 2007; Lee, 2009).

This study uses various geochemical proxies and statistical methods that are commonly applied in sedimentology for paleoenvironmental and provenance analyses (e.g. McLennan et al., 1993; Hofmann et al., 2001; Pearce et al., 2005; Rahman and Suzuki, 2007; Lee, 2009; Madhavaraju et al., 2010; Hofer et al., 2011). Several geochemical and statistical tools are tested to infer paleoenvironments, alteration, weathering, and provenance.

We analyzed the bulk rock geochemistry of fine-grained sediments of the upper Cretaceous to Paleogene Gosau Group (e.g. Wagreich and Faupl, 1994) that were deposited after the Eoalpine high pressure orogenic event at ca. 95 Ma (Thöni, 2006). They were deformed and dismembered by Paleogene to Neogene orogeny. The purpose of this study is to compare geochemical characteristics of the different Gosau deposits for separating out freshwater from marine sediments. We determine and differentiate provenance using major, trace, and rare earth elements.

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Peer-review under responsibility of China University of Geosciences (Beijing)

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http://dx.doi.org/10.1016/j.gsf.2012.11.009

2. Geological setting

The upper Cretaceous to Paleogene sediments of the Gosau Group of the Northern Calcareous Alps (NCA) are unconformably and diachronously overlying Permian to lower Cretaceous units that experienced folding and faulting (Wagreich and Faupl, 1994). The sediments can be divided into a fluvial, lacustrine to shallow-marine lower Gosau Subgroup (Turonian to Santonian/Campanian, in some areas up to Maastrichtian) and into a deep-water dominated up to Eocene upper Gosau Subgroup (Faupl et al., 1987; Wagreich and Faupl, 1994; Faupl and Wagreich, 1996). Originally the Gosau Group sediments were situated at the northern, tectonically active continental margin of the Austroalpine microplate along the northern margin of the Adriatic plate (Faupl and Wagreich, 2000). The Gosau basins represent strike-slip dominated slope basins within an early accretionary structure due to southward subduction of the Penninic Ocean (viz. Alpine Tethys of Stampfli et al., 2002). Today, the original palaeogeographic situation is largely obliterated due to polyphase tectonic deformation and large-scale thrusting within the Eastern Alps (e.g. Faupl and Wagreich, 2000).

Various Gosau Group deposits are exposed in the eastern part of the Eastern Alps (Austria) at the area of Gießhübl and Grünbach – Neue Welt (south-western margin of the Vienna Basin). They are also exposed in the western part of the Western Carpathians at the area of Brezová and Myjava, Slovakia (Fig. 1) (Wagreich and Marschalko, 1995). In between, NE–SW-striking Gosau sediments were drilled in several wells below the Neogene fill of the Vienna Basin (Wessely, 1993). The Gosau Group deposits were deformed during the Alpine orogeny and today forming synclines. From north to south several synclines on different tectonic nappes of the NCA and on Carpathian units are present. There are the northernmost Gießhübl Syncline, the Prottes Gosau Group, its Slovakian equivalents of Studienka, the Glinzendorf Syncline and the southernmost Grünbach Syncline (Plöchinger, 1961; Wessely, 1974, 1984, 1992, 1993, 2000, 2006; Wagreich and Marschalko, 1995; Zimmer and Wessely, 1996) (Fig. 1).

2.1. Tectonic position and sedimentary setting

The Gießhübl Syncline (Coniacian to Paleocene) is part of the Lunz Nappe of the Bajuvaric Nappe system (Faupl and Wagreich, 1996) of the NCA. It is dominated by deep-marine facies from the Campanian onward. In the Coniacian–Santonian shallow-marine sandstones and breccias are deposited, and are overlain by the Nierental Formation (upper Gosau Subgroup) of the upper Santonian-Campanian to lower Maastrichtian (Wessely, 2006). The group mainly consists of calcareous marls of pelagic to hemipelagic slope facies (Krenmayr, 1999; Wagreich and Krenmayr, 2005; Wagreich et al., 2011). The youngest unit is the Gießhübl Formation

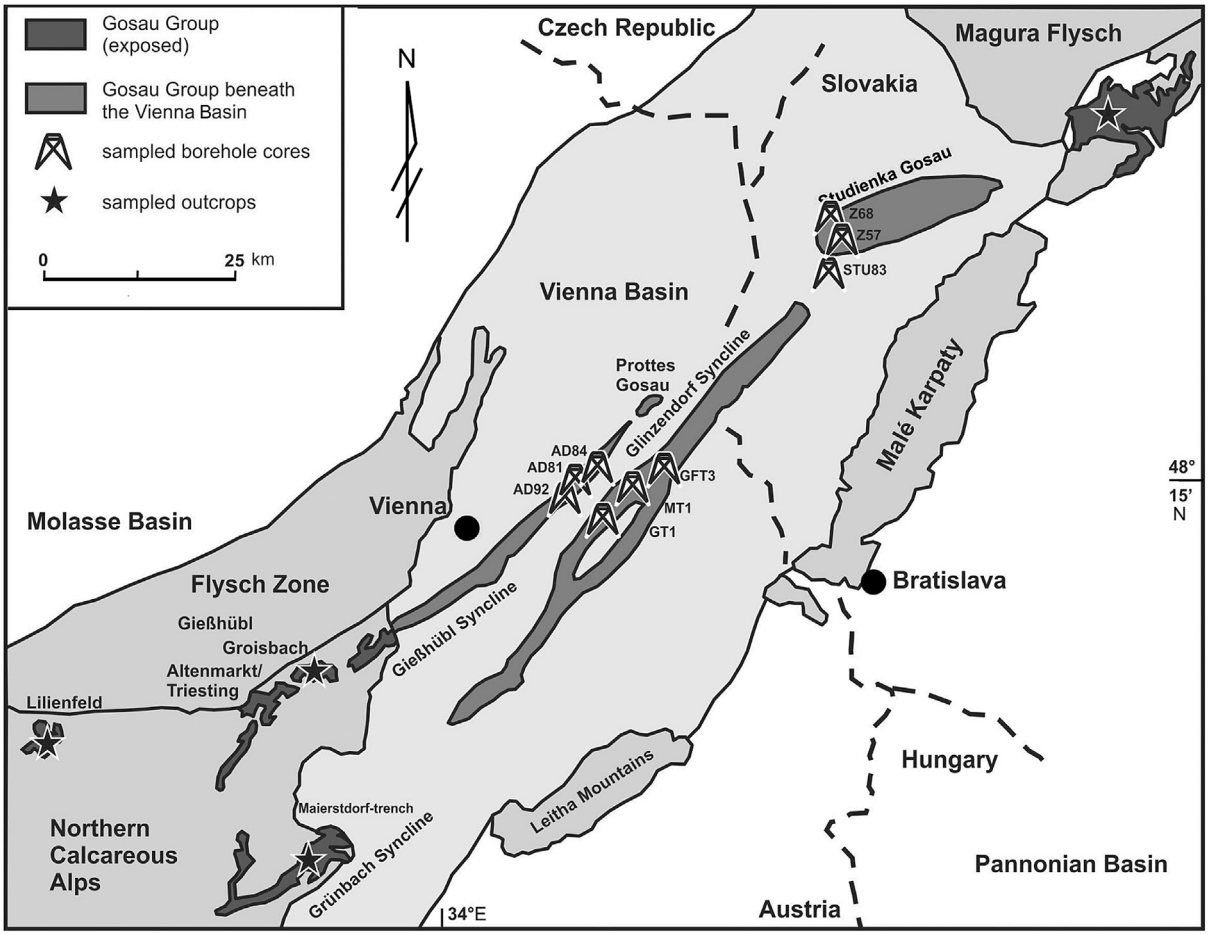

Figure 1. Simplified geological map of the eastern part of the Eastern Alps, the Vienna Basin and the western part of the Western Carpathians with highlighted Gosau Group situated at the border and underneath the Neogene Vienna Basin (modified after Wagreich and Marschalko, 1995; Zimmer and Wessely, 1996). The sampled locations of the wells and outcrops are marked.