

## Recent advances in multidisciplinary research at Höwenegg, Hegau, Germany (Late Miocene, MN9)

Raymond L. BERNOR<sup>1</sup> & Elmar HEIZMANN<sup>2</sup>

<sup>1</sup> College of Medicine, Department of Anatomy, Laboratory of Evolutionary Biology, Howard University, Washington D.C. 20059; <sup>2</sup> Staatliches Museum für Naturkunde, Stuttgart, Germany

Fossil vertebrates were first discovered at Höwenegg at the beginning of the 20<sup>th</sup> century, and the main site itself was discovered in 1936. It is renowned for its preservation of complete mammalian skeletons, including a number of females with fetuses in situ utero. The tridactyl horse *Hippotherium primigenium*, the archaic boselaphine antelope *Miotragocerus pannoniae*, and the rhinoceros, *Aceratherium incisivum* are all known from multiple skeletons, and a muntjak deer and a tragulid species are represented by partial skeletons. Small mammals are also represented by complete skeletons (*Prolagus oeningensis*; Tobien, 1986) and with the successes of our project, new tooth specimens.

Extensive, but episodic quarrying was undertaken between 1950 and 1963 under the joint direction of Professors Heinz Tobien (then, Darmstadt) and Erwin Jörg (Karlsruhe). A summary of Höwenegg's geology and paleontology was published by Tobien (1986), while descriptions of Höwenegg's stratigraphy, sedimentology and taphonomic context (Jörg and Rothausen, 1991; Woodburne et al., 1996), turtles (Schleich, 1986), carnivores (Beaumont, 1986), rhinoceroses (Hünemann, 1982), chalicotheres (Zapfe, 1989) and hipparionine horses (Bernor et al., 1997) have also been published.

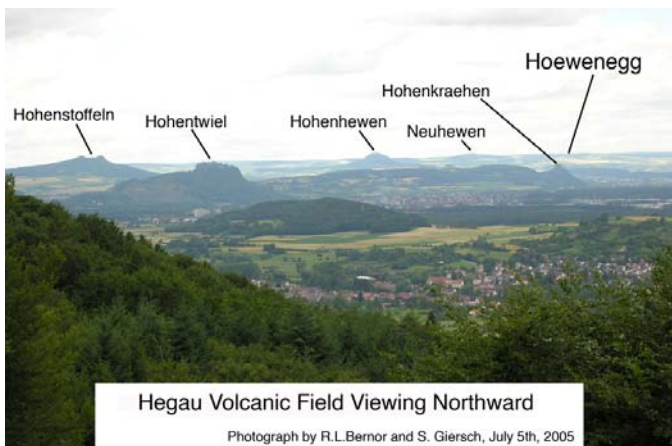
Until June, 2003 there had been no fossil excavations undertaken at Höwenegg since 1965. Yet, there are many outstanding, unresolved issues about the Höwenegg site, including further refinement of its actual chronometric age, the sedimentologic and taphonomic regimes under which the vertebrate skeletons were accumulated, and a complete, integrated reconstruction of Höwenegg's paleoenvironmental context. Also, there was the strong belief that further skeletons could be unearthed at Höwenegg. In order to address these outstanding issues, and to develop Höwenegg as the late Miocene vertebrate assemblage standard that it could be, it has been clear that new excavations need to be undertaken.

We reinitiated our research at Höwenegg in the Summer of 2003. Our objectives were to reopen an east-west trending 10 meter long geological trench at

the site and begin our exploration for new fossil remains of plant, invertebrate and vertebrate material. During the first week of excavation we discovered the distal limb elements of a *Miotragocerus* skeleton in the trench. In the second week we uncovered this specimen and found that it was a complete skeleton (female with two full term fetuses in situ utero). In very close association to this individual, we discovered a second *Miotragocerus* skeleton along with a complete skeleton of the turtle, *Trionyx*. In addition to these individuals we found abundant in situ remains of molluscs, leaves, fruits and a new species of fossil cervid. In 2004, we continued working in this trench and removed yet another skeleton of *Miotragocerus*, and more invertebrate and fossil plant material. In addition, we opened a six meter geological trench approximately 50 meters to the north and established for the first time, that fossiliferous Höwenegg deposits occur outside the classical collecting area. In this new trench we uncovered a rich fossil layer with remains of a land turtle (not *Trionyx*), a rhinoceros, fishes and stratigraphic horizons rich with gastropods and leaves. Our two year pilot project conclusively demonstrated that Höwenegg remains an immensely rich locality readily amenable to the recovery of further fossil remains and broad paleoenvironmental analyses (Heizmann et al., 2003). In 2004 a 22 meter deep core was drilled on the north edge of the new excavation and in close juxtaposition to the local basaltic intrusion. This core transected the complete Höwenegg section as well as the contact between the Höwenegg beds the underlying Tertiary sediments. A detailed stratigraphic and sedimentologic study of the core is being undertaken by Ruth Haas, University of Karlsruhe.

In the Summer of 2005 we undertook extensive excavations with scientific staff from the Natural History Museums of Karlsruhe and Stuttgart with the aim of gaining a better understanding of the spectacular accumulation of fossil vertebrates, invertebrates and diverse plant material at Höwenegg (Hegau), Southern Germany. The age of the Höwenegg

fossil accumulation has been securely established as being 10.3 Ma (Swisher, 1996), or slightly younger than this age. It is correlative with European Mammal Neogene Unit 9 (MN 9) and it has the potential for becoming an important paleobiological standard for the early late Miocene. The continued retrieval of articulated vertebrate skeletons, some with fetuses in situ utero, and an unprecedented retrieval of a diverse paleobotanical record means that at the Höwenegg we have the potential of securing a paleobiological reconstruction for the locality that is rare in the geological record (Heizmann et al., 2003).



**Fig. 1** — View of the Hegau volcanics from the northwest border of Lake Constance (Bodensee), with Höwenegg on the northern horizon.



**Fig. 2** — The new Höwenegg quarry.

The Höwenegg project has additionally developed a multidisciplinary structure, complete with working group leaders and collaborators that will organize work at the site and in the laboratory. Our research group includes the following individuals, by discipline:

**Geology** — Thomas Aigner (mapping, sedimentology); Ute Gebhardt (freshwater limestones), Ruth Haas (mineralogy and sedimentology), Wolfgang Munk (measuring and documentation of sections), Sherry Nelson (stable isotopes)

**Working group for plants (leader J. Eder)** — Johanna Eder (leaves), Samuel Giersch (leaves, taphonomy), Marianna Slamkova (pollen and spores), Veronika Wähnert (seeds), Caroline Strömberg (phytolithes).

**Working group for invertebrates (leader M. Rasser)** — Günter Bechly (insects), Gabriele Gruber (ostracods), James H. Nebelsick (taphonomy), Michael W. Rasser (gastropods), Günther Schweigert (crustaceans excluding ostracods).

**Working group for vertebrates (Co-leaders R.L. Bernor and E. Heizmann)** — Raymond L. Bernor (Mammalia, Primates [with E. Heizmann], Equidae and Chalicotheriidae [this last with J. Franzen]); Ronald Böttcher (fishes), Oldrich Fejfar (microvertebrates, rodents, lagomorphs); Jens Franzen (Chalicotheriidae, with R.L. Bernor), Eberhard Frey (non-tetrapod vertebrates, taphonomy), Ioannis Giaourtsakis (Rhinocerotidae), Elmar P.J. Heizmann (Mammalia, Primates [with R.L. Bernor], Carnivores, Artiodactyla), Bettina Reichenbacher (otolithes), Reinhard Ziegler (microvertebrates, insectivores).

**Working group for data analysis (leader H.W. Mittmann).**

Our results to date include: the discovery of new skeletons of fossil vertebrates; development of a new 100 square meter quarry immediately adjacent to Tobien and Jörg's quarry with the aims to correlate the stratigraphy, undertake detailed sedimentologic studies, and retrieval of all biotic elements; retrieval of diverse invertebrate materials, including the first beetle; retrieval of diverse fossil plant material including leaves, fruits and seeds; retrieval of small mammal material useful for striking more refined biochronologic correlations with Central and Western European localities and to further resolve paleoenvironmental reconstructions of the site; initiation of carbon and oxygen isotope studies of existing mammalian enamel material to gain new insights into Höwenegg mammalian paleodiet.

## References

- Beaumont, G. de 1986. Les carnivores (Mammifères) du Néogène de Höwenegg (Hegau, Baden-Württemberg). *Carolinea*, 44: 35-43.
- Bernor, R.L., Tobien, H., Hayek, L.A. & Mittmann, H.-W. 1997. The Höwenegg Hipparionine Horses: Systematics,

- Stratigraphy, Taphonomy and Paleoenvironmental Context. *Andrias*, 10: 1-230.
- Heizmann, E.P.J., Munk, W., Ziems, A., Bernor, R.L. & König, H. 2003. Neue Grabungen am Höwenegg (Gemeinde Immendingen, Landkreis Tuttlingen, Baden-Württemberg) Bericht über die Pilotgrabung vom 16. 6. 2003 bis zum 11. 7. 2003. *Carolinea*, 61: 5–16.
- Hünemann, K.A. 1982. Die Nashornskelette (*Aceratherium incisivum* Kaup 1832) aus dem Jungtertiäre vom Höwenegg im Hegau (Südwestdeutschland, Vallesium, Obermiozän). *Andrias*, 8: 13-64.
- Jörg, E. 1965. *Ophiosaurus acuminatus* nov. spec. (Anguidae, Rept.) von der pontischen Wirbeltierfundstätte Höwenegg (Hegau). *Beitr. naturk. Forsch. SüdwDtl.*, 24: 21-30, 6 Abb., 1 Taf.; Karlsruhe.
- Jörg, E., Rest, H. & Tobien, H. 1955. Die Ausgrabungen der Jahre 1950-1954 an der jungtertiären Fossilfundstelle Höwenegg/Hegau. *Beitr. naturkundl. Forsch. Südwestdeutschland.*, 14: 13.
- Jörg, E. & Rothausen, K. 1991. Zur Schichtfolge und Biostratonomie der Wirbeltierfundstelle Höwenegg (Hegau, Südwestdeutschland, Vallesium, Obermiozän). *Andrias*, 8: 13-64.
- Nelson, S.V. 2003. The extinction of *Sivapithecus*: the faunal and environmental changes surrounding the disappearance of a Miocene hominoid in the Siwaliks of Pakistan. *American School of Prehistoric Research*, Monograph Series. Vol. 1: 1-136.
- Schleich, H.H. 1985. Zur Verbreitung tertiärer und quartärer Reptilien und Amphibien. I. Süddeutschland. *Münchner Geowiss. Abh. (a)*, 4: 67-149.
- Schleich, H.H. 1986. Vorläufige Mitteilung zur Bearbeitung der fossilen Schildkröten der Fundstelle Höwenegg. *Carolinea*, 44: 47-56.
- Swisher, C.C. III. 1996. New <sup>40</sup>Ar/<sup>39</sup>Ar dates and their contribution toward a revised chronology for the late Miocene nonmarine of Europe and west Asia. In: R.L. Bernor, V. Fahlbusch & H.-W. Mittmann (eds.), *The Evolution of Western Eurasian Later Neogene Faunas*; Columbia University Press, New York. pp. 64-77.
- Tobien, H. 1957. Die Bedeutung der unterpliozänen Fossilfundstelle Höwenegg für die Geologie des Hegaus. *Jb. Geol. Landesamt, Bad.-Württ.* 2: 193-208.
- Tobien, H. 1986. Die jungtertiäre Fossilgrabungsstätte Höwenegg im Hegau (Südwestdeutschland). Ein Statusbericht. *Carolinea*, 44: 9-34.
- Tobien, H. & Jörg, E. 1959. Die Ausgrabungen an der jungtertiären Fossilfundstätte Höwenegg (Hegau) 1955-1959. *Beitr. Naturkdl. Forsch. SüdwDtl.* 18:175-191.
- Woodburne, M.O., Bernor, R.L. & Swisher, C.C. III. 1996. An Appraisal of the Stratigraphic and Phylogenetic Bases for the „Hipparion Datum“ in the Old World. In: R.L. Bernor, V. Fahlbusch & H.-W. Mittmann (eds.), *The Evolution of Western Eurasian Later Neogene Faunas*; Columbia University Press, New York. pp. 124-136.
- Zapfe, H. 1989. *Chalicotherium goldfussi* Kaup aus dem Vallesium vom Höwenegg im Hegau (Südwestdeutschland). *Andrias*, 6: 117-128.