

# Geoloogia instituudi 2018. aasta teadus- ja arendustegevuse aruanne

## Department of Geology

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Geoloogia instituudi koosseisu kuulub 5 uurimisrühma, teaduskogude osakond ja Särghaua maateaduste õppekeskus:

- aluspõhjageoloogia osakond
- isotoopgeoloogia osakond
- kvaternaargeoloogia osakond
- maavarade- ja rakendusgeoloogia osakond
- mäeosakond

The Department of Geology consists of five research groups, the Division of Collections and Särghaua Earth Science Centre:

- Division of Bedrock Geology
- Division of Isotope Geology
- Division of Mineral Resources and Applied Geology
- Division of Mining
- Division of Quaternary Geology

## Teadustegevuse ülevaade uurimisrühmade lõikes

### Aluspõhjageoloogia osakond

Juht: professor OLLE HINTS, [olle.hints@taltech.ee](mailto:olle.hints@taltech.ee)

Liikmed: Peep Männik, Jaak Nõlvak, Aivo Lepland, Dimitri Kaljo, Linda Hints

Järel doktor: Yan Liang

Doktorant: Ursula Toom, Liina Antonovitš, Garmen Bauert, Heikki Bauert

Uurimisrühma tegevust iseloomustavad võtmesõnad:

Paleosoikumi geoloogia, paleontoloogia, paleo-keskkond, isotoobid

Aluspõhja geoloogia, sh stratigraafia ja paleontoloogia, on olnud Geoloogia Instituudi üheks keskseks uurimisvaldkonnaks alates instituudi loomisest. 2018. a on osakonnaga seotud 4 teadustöötajat, järel doktor Hiinast ja 4 doktoranti, teadustegevus toimub Eesti Teadusagentuuri uurimistoetuse jt projektide toel. Osakonna töötajad osalevad mitmete loengukursuse läbiviimisel "Maapõueressursside" õppekava üliõpilastele.

Aluspõhja osakonna põhikompetentside hulka kuulub Eesti geoloogilise ehituse, kivimite, kivistite ja arenguloo põhjalik tundmine. Sellised teadmised on vajalikud praktilises geoloogias, kuid põhiliselt leiavad kasutust siiski alusuuringutes, enamasti tihedas rahvusvahelises koostöös. Osakonna peamiste uurimissuundade hulka kuuluvad:

- mikropaleontoloogia ja detailne biostratigraafia;
- elurikkuse dünaamika modelleerimine ja elurikkuse seosed kliima ja keskkonnamuutustega;
- erinevate organismirühmade evolutsioon ja paleobiogeograafilise leviku analüüs;
- paleokliima modelleerimine kasutades sedimentoloogilisi ja geokeemilisi indikaatoreid;
- Paleosoikumi vulkanism, bentoniidikihtide levik ja geokeemia ning stratigraafiline rakendus;

- süsiniku aineriinge muutused Paleosoikumis ning isotoopgeoloogiliste meetodite kasutusvõimalused selle selgitamiseks;
- geodünaamika, magma- ja moondeprotsesside modelleerimine.

Oluline osa aluspõhja osakonna teadustööst baseerub instituudi geoloogilistel ja paleontoloogilistel kollektsioonidel, mida haldab teaduskogude osakond.

Olulisemad 2018. a teadustulemused: Uued andmed Vara-Paleosoikumi mikrofossiilide kohta aitasid selgitada kitiinikute ja konodontide paleoelurikkuse dünaamika arengut ja paleoökoloogiat ning biostratigraafilist levikut erinevates piirkondades, eeskätt Baltika ja Lõuna-Hiina kontinendil. Esmakordselt tehti kokkuvõtte Eesti Ordoviitsiumi-Siluri karbonaatse settebasseini jäljekivististe taksonoomia ja leviku kohta, mis näitas jäljetekitajate seni arvatust suuremat mitmekesisust ja arvukust. Baltikumi Ordoviitsiumi brahiopoodikoosluste uuring selgitas välja koosluste leviku seaduspärasused ning näitas maksofossiilide jätkuvat kasutatavust nii paleobiogeograafias kui biostratigraafias. Taksonoomiliselt kirjeldati mitmeid uusi taksoneid lõuatute, kalade, okasnahksete, jäljekivistste ning kitiinikute hulgas. Süsiniku ja väevli stabiilsete isotoopide geokeemia uuringud koostöös partneritega näitasid basseiniliste ja diageneetiliste tegurite olulisust ning seda, et vaid osa isotoop-geokeemilisi mustreid on seotud globaalsete kliima- ja keskkonnamuutustega.

### Division of Bedrock Geology

Head: Professor OLLE HINTS, [olle.hints@taltech.ee](mailto:olle.hints@taltech.ee)

Members: Peep Männik, Jaak Nõlvak, Aivo Lepland, Dimitri Kaljo, Linda Hints

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Keywords: Paleozoic geology, paleontology, paleoenvironment, isotopes

Bedrock geology, including paleontology and stratigraphy, have been among the key research areas of the Department of Geology since 1950s. As of 2018, the group includes four researchers, postdoc and four PhD students, who work in close collaboration with partners worldwide, notably in US, Russia, Sweden, China, Canada, France, Belgium, Germany and UK.

The main research topics of the group are related to deciphering Earth history through the latest Proterozoic and early Paleozoic times, ca 600–400 million years ago. During this period the planet underwent major transitions in climate systems and environments, related to changing oxygen levels and perturbations in carbon cycle rarely seen on Earth since then. This interval moreover embraced key events in biological evolution and biodiversification, such as the Cambrian explosion and Ordovician radiation, but witnessed also one of the largest mass extinctions in the history of life. The group is interested in better understanding the interactions between geo- and biosphere processes, in particular, addressing the following:

- paleobiodiversity dynamics and its relationships with climate and environmental changes;
- paleobiology and evolution of various groups of organisms during early Palaeozoic;
- global paleobiogeographic patterns and the role of the Baltic faunal province;
- paleoclimate perturbations using multiple proxy indicators (such as conodont apatite);
- changes in carbon, oxygen and sulfur stable isotope composition, reflecting of atmosphere and hydrosphere in deep time.

The group holds leading palaeontological competence in Estonia, and for some fossil groups, leading expertise worldwide (notably for conodonts, chitinozoans and scolecodonts). The main applications of the group's work are related to the high-resolution biostratigraphy of Early Paleozoic sedimentary rocks, which has resulted in numerous collaborative publications. Most higher-impact studies are nevertheless based on material from the Baltoscandian bedrocks, renowned by little alteration and excellent preservation primary Paleozoic signatures. Studies conducted at the department have been published in leading research journals including Nature, PNAS and Geology.

The group is responsible for running the mass spectrometry lab for stable isotope geochemistry, SEM for imaging and express geochemistry as well as paleontology lab for extracting microfossils. The group makes also excessive use of the geological and paleontological collections held at the department. These are largest in Estonia and curated at a high international level.

Main results 2018: New data on Early Palaeozoic microfossils enabled better understanding of chitinozoan and conodont biodiversity dynamics and paleoecology, and improved biostratigraphic constraints across different regions, notably Baltica and South China. For the first time the taxonomy and distribution of carbonate facies ichnofossils in Estonia were reviewed, highlighting a notably higher diversity and role of trace makers than previously known. Carbon and sulfur stable isotope studies of the Silurian strata showed that basin-scale variations and diagenetic overprints have to be taken into account when interpreting the curves and that only some of the trends bear global signature.

#### Major publications 2018:

- **Hints, O., Antonovitš, L., Bauert, G., Nestor, V., Nõlvak, J., Tammekänd, M.** 2018. CHITDB: a database for documenting and analysing diversification of Ordovician–Silurian chitinozoans in the Baltic region. *Lethaia* **51**, 218-227.
- **Liang, Y., Hints, O., Luan, X., Tang, P., Nõlvak, J., Zhan, R.** 2018. Lower and Middle Ordovician chitinozoans from Honghuayuan, South China: Biodiversity patterns and response to environmental changes. *Palaeogeography, Palaeoclimatology, Palaeoecology* **500**, 95-105.
- **Toom, U., Vinn, O., Hints, O.** 2018. Ordovician and Silurian ichnofossils from carbonate facies in Estonia: a collection-based review. *Palaeoworld* **xx**, xx-xx. Published online: 17. July 2018.

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## Isotoopgeoloogia osakond

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Doktorant: Joonas Pärn

#### Uurimisrühma tegevust iseloomustavad võtmesõnad:

stabiilsed isotoobid, põhjavesi, paleoklimatoloogia, CO<sub>2</sub> kinnipüüdmine ja ladustamine

Isotoopgeoloogia osakond moodustati Geoloogia Instituudis eelmise sajandi 70-ndate aastate algul eesmärgiga kasutada isotoop-geokeemilisi analüüsimeetodeid ja indikaatoreid globaalsete kliima- ja keskkonnamuutuste uurimisel. Osakonna algusaastatel kujunes põhiliseks uurimissuunaks paleoklimatoloogia ja eelkõige polaaralade jääpuursüdamikes talletunud isotoopandmestiku dešifreerimine. Viimase aastakümne jooksu on osakonna isotoopuuringud laienenud ja hõlmavad enda alla põhjavee isotoopkoostise, vanuse ja päritolu probleemid ning numbriliste mudelite rakendamist. Jätakuvalt ollakse edukad polaaralade isotoop-põhiste paleokliima- ja keskkonnamuutuse lahendamisel. Uue uurimissuunana on lisandunud CO<sub>2</sub> sidumine ja geoloogiline ladustamise temaatika.

2018. a alguse seisuga on osakonnaga seotud 5 teadustöötajat, 1 doktorant, 2 teaduskraadiga tehnilist töötajat. Teadustöö toimub Eesti Teadusagentuuri uurimistoetuste ja välisprojektide, sh EL Horisont 2020 projektide toel. 2018.a sõlmiti Keskkonnaministeeriumiga aastane uurimislepung nitraatide ja pestitsiidide kõrgendatud sisalduse põhjuste ja leviku ulatuse väljaselgitamiseks Siluri-Ordoviitsiumi põhjaveekogumis Ida-Eesti vesikonnas. Osakonna töötajad osalevad mitme õppeaine õpetamisel „Maapõueressursside“ õppekava üliõpilastele. Osakonnal on teadustöökäsi välja arendatud kaasaegne isotoop-geokeemiliste analüüsise infrastruktuur, sh kaks firma Thermo Fisher Scientific stabiilsete isotoopide suhte mõõtmise massispektromeetrit ja ionkromatograaf ICS-1100. Välispartnerite kaudu on osakonnal juurdepääs ka unikaalsele veeproovide vääriskaaside sisalduse ning vääriskaaside isotoopanalüüsise aparatuurile.

Olulisemad 2018. a teadustulemused: Joonas Pärn kaitses doktoritöö „Paleopõhjavete päritolu ja geokeemiline areng Baltiarteesiabasseini põhjaosas“. Töö tulemused kinnitasid liustikutekkelise

paleopõhjavee laialdast levikut Kambriumi-Vendi põhjaveekompleksil lasuvates põhjaveekompleksides. See kajastub eelkõige põhjavee kerges isotoopkoostises. Liustikutekkelise paleopõhjavee lai levik Eesti aluspõhjas tähendab ka seda, et Eesti põhjavee kasutamist reguleerivad põhimõtted ja seadusandlus vajavad ülevaatamist. Selgitati välja CO<sub>2</sub> kinnipüüdmise, taaskasutamise ja ladustamise (CCUS) tehnoloogiat soodustavad ja takistavad tegurid Balti mere regioonis. Pakuti välja mandriline CCUS stsenaarium Eesti suurimate emiteerijate CO<sub>2</sub> emissioonidele. Eelnimetatud stsenaarium aitab Eestil saavutada oma strateegilisi kliimaeesmärke.

## Division of Isotope Geology

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Doctoral student: Joonas Pärn

Keywords: stable isotopes, groundwater, paleoclimatology, CO<sub>2</sub> capture and storage

The Division of Isotope Geology was formed in the early 1970s with the aim of using isotopic and geochemical indicators in polar ice-cores for the study of global climatic variability and environmental changes back in time. Over the years, the division's main research areas have been expanded to hydrogeology, arctic paleoclimatology and environmental change, high-resolution stable isotope Paleozoic chemostratigraphy as well as CO<sub>2</sub> capture and storage.

As of 2018, the division's research work will be carried out on Estonian Research Council projects, several international projects (including EU Horizon 2020) and contracted projects. The research staff includes five researchers, one doctoral student and two engineers holding PhD degrees. The division holds a modern research facility with an international client base including: two Thermo Fisher Delta V Advantage IRMS, with three sample preparation lines (GasBench II for  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  from carbonate rocks; FlashEA 1112 for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  analyses from organic matter and TC/EA High Temperature Conversion/Elemental Analyzer), and Thermo Dionex ionchromatograph ICS-1100.

Currently the studies of the research group are focused on:

- groundwater flow conditions, global paleoclimate signals and anthropogenic influence in the Baltic Artesian Basin: a synthesis of numerical hydrogeological models and hydrogeochemical data;
- polar paleoclimate change;
- CO<sub>2</sub> geological storage and numerical modelling of storage sites.

Main results 2018: Joonas Pärn defended PhD degree (Origin and Geochemical Evolution of Palaeogroundwater in the Northern Part of the Baltic Artesian Basin). It was established that groundwater in the O-Cm aquifer system is weakly connected to the modern hydrologic cycle and that the aquifer system contains paleogroundwater that probably originates from a period that encompasses both the Last Glacial Maximum (LGM) and the pre-LGM period. Such a wide distribution of glacial paleogroundwater in the northern Baltic Artesian Basin is unique in Europe. The wide spread of glacial derived groundwater in Estonia has important implications for groundwater management and their sustainable use should be protected with appropriate legislation to avoid overexploitation. Drivers and barriers for implementation of Carbon Capture, Utilisation and Storage (CCUS) technology in the Baltic Sea Region was clarified. The onshore CCUS scenario was proposed for CO<sub>2</sub> emissions produced and captured by the largest CO<sub>2</sub> emitters in Estonia. Such scenario will support Estonia to reach their climate strategic targets.

Major publications 2018:

- **Pärn, J.**, Affolter, S., **Ivask, J.**, Johnson, S., Kirsimäe, K., Leuenberger, M., **Martma, T.**, **Raidla, V.**, Schloemer, S., Sepp, H., **Vaikmäe, R.**, Walraevens, K. 2018. Redox zonation and organic matter

oxidation in palaeogroundwater of glacial origin from the Baltic Artesian Basin. *Chemical Geology* **488**, 149-161.

- Sterckx, A., Lemieux, J.-M., **Vaikmäe**, R. 2018. Assessment of paleo-recharge under the Fennoscandian Ice Sheet and its impact on regional groundwater flow in the northern Baltic Artesian Basin using a numerical model. *Hydrogeology Journal* **26**, 2793-2810.
- Zdanowicz, C., Karlsson, P., Bekholmen, I., Roach, P., A.Poulain, A., Yumvihoze, E., **Martma**, T., Ryjkov, A., Dastoor, A. 2018. Snowmelt, glacial and atmospheric sources of mercury to a subarctic mountain lake catchment, Yukon, Canada. *Geochimica et Cosmochimica Acta* **238**, 374-393.

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## Maavarade- ja rakendusgeoloogia osakond

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Doktorandid: Siim Pajusaar, Tõnu Tomberg

### Uurimisrühma tegevust iseloomustavad võtmesõnad:

maavarad, geotehnika, andmebaasid

Uurimisrühma tegevuses on kesksel kohal Eesti nn tuleviku maavarade geokeemilise koostise, geneesi ja leviku uuringud. Teiseks oluliseks tegevusvaldkonnaks on kaevandamisega ja militaarobjektidega seotud geotehnilised uuringud. Neile lisanduvad maapõue ja merekeskkonna keskkonnaseisundit, maavarade efektiivsemaid rikastamistehnoloogiaid ja geoloogiliste andmete digitaalset kättesaadavust edendavad projektid.

Esiletõstmist väärib rühma mitmekülgne kompetents orgaanikarikaste setteliste maavarde, sh põlevkivide, mustade kiltade ning turba, aga ka karbonaatsete kivimite geoloogilistes uuringutes. Töörühm omab ühtlasi pikaajalist kogemust paleokeskkondade ja settekivimite tekkeprotsesside käsitlemises, sealhulgas paleosoiliste vulkaanilis-setteliste kivimite stratigraafia ja elementide mobiilsuse ning Ordoviitsiumi ja Siluri kliima ja mereliste tingimuste interpreteerimisel. Geotehniliste uuringute valdkonnas on töögrupi põhifookuseks lõhketööd ja viimastega seotud vibratsiooni uuringud.

Osaletakse RITA strateegilise TA toetamise projekti raames Eesti fosforiidi rikastamise ja aluskorra potentsiaalsete metalliressursside uuringutes. Käimasolevate arendusprojektide hulka kuulub ka maagiotsingute kompleksiteabe jagamist ja analüüsi toetava veebipõhise õppeotstarbelise infosüsteemi loomine. EIT Raw Materials'i vahenditest finantseeritava (Horisont 2020) projekti raames arendatav infosüsteem on unikaalne digilahendus, mis koondab erinevat tüüpi uuringuandmeid partneritelt üle Euroopa.

Osakonna T&A tegevus tugineb instituudi kaasaegsel analüütilisel kompleksil (XRD, XRF, ICP-MS, SEM-EDS), mis lubab teostada erinevaid kivimite ja maavarade geokeemilisi, mineraloogilisi ja petrograafilisi uuringuid. Lisandub võimekus maavarde füüsikalise-keemiliste omaduste in situ uuringuteks välitöödel ja puursüdamikest ning geoloogiliste protsesside analoogmodelleerimine.

Uurimisrühma aktiivsete koostööpartnerite hulka kuuluvad töögrupid Eesti Geoloogiateenistusest, Tartu Ülikoolist, Soome Geoloogiateenistusest ning mitmest välisülikoolidest ja TTÜ allüksustest, sh materjali- ja keskkonnatehnoloogia instituudist ning põlevkivi kompetentsikeskusest.

Olulisemad 2018. a teadusprojektid:

- Sillamäe piirkonna graptoliitargilliidi ja Jõhvi rauamaagi leiukoha metallide leviku kaardistamine ja geneesi uuringud, eskiislahendused Tallinn-Helsingi tunneli läbindamistödeks settekivimites;
- EIT RM projekti EUROCORE õppeotstarbelase maagiotsingu andmebaasi valmimine;
- Maavarade spektroskoopiliste laboratoorsete ja in-situ analüüside kvaliteedi tõstmine, sh osalemine rahvusvahelistel geoanalüütilistel võrdluskatsetel ja uute standardproovide valmistamine.

## Division of Mineral Resources and Applied Geology

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Doctoral students: Siim Pajusaar, Tõnu Tomberg

Keywords: mineral resources, geotechnical engineering, databases

The research group mainly deals with subjects concerning future mineral resources of Estonia, targeting issues related to genesis and physical-chemical characteristics of the potential deposits, but as well with geotechnical problems related to mining and military applications. Moreover, a number of projects dealing with environmental geology, enrichment technologies of mineral raw materials, as well as with development of data systems for digital sharing of geological information, have been carried out during last few years.

The core competences of the work group are related to geology of organic rich mineral resources (black shales, oil shales, peat) as well as sedimentary calcareous rocks. On the field of the geotechnical engineering studies on blasting technique and vibration have been the primary focus of the work group.

New research activities were launched as part of EU-funded strategic R&D initiative targeting enrichment of shelly phosphorite resources, Ordovician black shales and exploration of potential ore deposits of Estonian crystalline basement.

As part of the project funded by EIT Raw Materials initiative (Horizon 2020) the work group is developing web-based educational information system for sharing core logging data. The system is designed to provide common access point to complex analytical datasets of mineral exploration collected with traditional and novel core logging techniques by different research institutions across Europe.

The work group manages modern analytical facilities including ICP-MS, XRF and XRD labs, allowing complex set of geochemical, mineralogical and petrological studies to be carried out. Other research capabilities include fieldwork instruments for in situ studies of geochemical properties of rocks, complemented by analogue modelling of geological processes.

The active collaboration partners of the work group come from numerous organizations from Estonia and abroad, including Estonian Geological Survey, University of Tartu, Estonian University of Life Sciences, Finnish Geological Survey and University of Lorraine.

Main projects in 2018:

- studies of metallogenesis in graptolite argillite from Sillamäe region and in Jõhvi magnetite-quartzite deposit, primary solution for tunnelling in sedimentary rock section of Tallinn-Helsingi tunnel;
- creation and implementation of educational ore exploration database;
- assurance of quality of laboratory and in-situ spectroscopic analysis; development new in-house standards and participating in proficiency testing programme of the International Association of Geoanalysts.

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## Mäeosakond

Uurimisrühma juht: professor MICHAEL HITCH, [michael.hitch@taltech.ee](mailto:michael.hitch@taltech.ee)

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Doktorant: Karin Robam, Andrus Paat, Nthathi Monei

### Uurimisrühma tegevust iseloomustavad võtmesõnad:

kaevandustehnika; ringmajandus; virtuaalne- ja liitreaalsus

TTÜ geoloogia instituudi mäeosakonnale pandi alus 1938. a, kui ülikoolis loodi mäeinseneride koolitamiseks mäeosakond. Ülikooli viimase struktuurireformi käigus liideti 2016. a septembris senine energeetikateaduskonna mäeinstituut geoloogia instituudiga omaette osakonnana. 2018 a alguse seisuga töötab osakonnas kuus doktorikraadiga teadustöötajat/õppejõudu. Mäeosakonna õppejõud annavad olulise panuse „Maapõueressursside“ õppekava õpetamisel, seda nii bakalaureuse kui ka magistritasemel. Osakonna teadustöö toimub peamiselt läbi riiklike kui ka ettevõtete rahastatud rakendusüritingute projektide. Osakonna tegevusega on tihedalt seotud riiklikult akrediteeritud mäetingimuste labor, mille kompetentside hulka kuulub muuhulgas maavõngete seismograafiline uurimine, mürasõõdistamised läbi helirõhu taseme mõõtmise, markseidermõõtmised, kivimite ja täitematerjalide geomeetriliste omaduste määramine ning purunemiskindluse määramine Los Angeles meetodil jmt.

Mäeosakonna kompetentsi kuulub :

- kaevanduste ja maavarade töötlemise tehnoloogiate projekteerimine;
- ressursitõhususe meetmete ja tehniliste lahenduste leidmine ning hindamine;
- ringmajandusega seotud ettevõtlussuundade arendamine.

2018 a T&A olulisematest arendusprojektidest väärivad märkimist:

- mehhaniseeritud laavakompleksi kaevis rikastamisvõimaluste uuring;
- turbaalaste uurimistulemuste digitaliseerimine ja andmebaasi koostamine II etapp (jätkuprojekt);
- lubjakivi killustiku ning tuha tehniline sobivus ja majanduslik põhjendatus raudteede ja kõrvalteede alusmaterjalina;
- ettevõtlikkus ringmajanduse suunaga integreeritud materjalide töötlemises.

Mäeosakonna vanemteadur Veiko Karu, kes on Euroopa Tehnoloogia- ja Innovatsiooninstituudi (EIT) teadus- ja innovatsiooni kogukondade teaduskoostöö võrgustiku (EIT Raw Materials) Taltech poolsete tegevuste koordinaator, algatas ja viis läbi mitmeid maavaratööstuse innovatsiooniga seotud alamprojekte:

- Visual3D projekt, mille raames tegeleti kolmemõõtmeliste geoloogiliste visualiseerimismudelite loomisega ning analüüsiga;
- VR-MINE projekt, mille raames loodi virtuaal reaalsuse kaevandusprojekt, mida kasutatakse õppetöös uute innovaatiliste kaevandamistehnoloogiate arendamiseks;
- RM@Schools3.0 projekt on kooliõpilastele suunatud maapõuealane projekt;
- ADMADP on doktoriõppeprogramm, kus doktorandid uurivad ja arendavad uusi tehnikaid ja tehnoloogiaid materjalitehnoloogia valdkonnas.

### **Division of Mining**

Head: Professor MICHAEL HITCH, [michael.hitch@taltech.ee](mailto:michael.hitch@taltech.ee)

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Doctoral students: Karin Robam, Andrus Paat, Nthathi Monei

**Keywords:** mining engineering; circular economy; virtual and augmented reality

Division of Mining has a long history, its activities began in 1938. In autumn 2016 in the course of structural reformation, the independent Institute of Mining was joined to Department of Geology. Nowadays research and education staff of division run research and lectures topics by occupational qualifications system of mining engineering (permissions given by Estonian Qualifications Authority), developing the necessary skill set for mining engineers. In 2018 TalTech elected Michael Hitch to Mining Engineering tenure track position professor.

Division of Mining competences are in field of geotechnology and mining engineering, economical evaluation in mineral exploration, mineral processing (design of separation technologies), sustainable use of mineral resources, environmental protection and circular economy in minerals usage.

Division of Mining is equipped with Laboratory of Mining Conditions and mining related softwares for design and modelling mining works and plans. Laboratory equipment is used widely in education and research projects.

Department of Geology is responsible to represent TalTech in EIT Raw Materials, initiated by the EIT (European Institute of Innovation and Technology) and funded by the European Commission. This network is the largest and strongest consortium in the raw materials sector worldwide. Its vision is the European Union where raw materials are a major strength. TalTech is core member of EIT Raw Materials. TalTech have partnership in 20 educational and research oriented projects in 2018.

Some significant innovation projects in EIT Raw Materials include:

- Visual3D – One tool to trigger a higher degree of investment in exploration and to secure ultimately the domestic supply of both main commodities and critical raw materials is to enhance our understanding of the Earth's crust below the surface;
- VR-MINE - Project addresses integrating Virtual Reality into European mining education. The underground environment of VR-Mine will be based on a real tungsten mine in Mittersill (Austria). Application of VR enriches didactic approaches used in raw materials teaching and mining education;
- RM@Schools3.0 is a Wider Society Learning project, focused on an innovative program to make science education and careers in RM attractive for youngster. An active learning will be proposed to schools by RM Ambassadors by involving students in experiments with RM-related hands-on educational kits, in excursions in industries, and in science dissemination activities.
- ADMADP develops the doctoral training in the existing Advanced Materials Doctoral Programme (ADMA-DP) to fulfill the quality criteria of the EIT-labelling in doctoral training.

Major publications 2018:

**Hitch**, M., Lytle, M., Tost, M. 2018. Social licence: power imbalances and levels of consciousness – two case studies. *International Journal of Mining, Reclamation and Environment* **xx**, xx-xx. Published online: 05. December 2018.

Li, J., **Hitch**, M. 2018. Mechanical activation of magnesium silicates for mineral carbonation, a review. *Minerals Engineering* **128**, 69-83.

Tost, M., Bayer, B., **Hitch**, M., Lutter, S., Moser, P., Feiel, S. 2018. Metal mining's environmental pressures: a review and updated estimates on CO<sub>2</sub> emissions, water use, and land requirements. *Sustainability* **10**, 2881.

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## Kvaternaarigeoloogia osakond

Uurimisrühma juht: professor SIIM VESKI, [siim.veski@taltech.ee](mailto:siim.veski@taltech.ee)

Liikmed: Tiiu Alliksaar, Atko Heinsalu, Anatoli Molodkov, Anneli Poska, Triin Reitalu, Jüri Vassiljev, Leeli Amon-Veskimeister

Doktorandid: Ansis Blaus, Mariliis Eensalu, Merlin Liiv, Vladimir Karpin

Uurimisrühma tegevust iseloomustavad võtmesõnad:

Pärastjääaegsed kliima- ja keskkonnamuutused, inimõju, liigiline mitmekesisus



Kvaternaari geoloogia ja sellega liituvad erialad on olnud geoloogia instituudi üheks oluliseks uurimisvaldkonnaks alates instituudi loomisest 1947. a. 2018. a on osakonnaga seotud seitse teadustöötajat, järel doktor ja neli doktoranti, teadustegevus toimub peamiselt Eesti Teadusagentuuri uurimistoetuste toel. Osakonna kõik töötajad osalevad mitmete loengukursuse läbiviimisel "Maapõueressursside" õppekava üliõpilastele.

Töögrupi teadustulemused on pärvinud rahvusvahelise tunnustuse ja on võimaldanud viljakat ühistööd mitmete oma ala maailma juhtivate teaduskollektiividega, pakkudes uudseid lahendusi pärastjääegse taimestiku, kliima, inimtegevuse ja keskkonnamuutuste vaheliste seoste väljaselgitamisel. Töögrupi arendustöö on avardanud võimalusi koostööks teiste teadusharudega nagu klimatoloogia, ökoloogia ja arheoloogia. Osakonna teadurid publitseerivad oma teaduseriala tippajakirjades nagu Nature Communications, Global Change Biology, Quaternary Science Reviews, Journal of Quaternary Science, Journal of Biogeography ja Journal of Vegetation Science.

Osakonna peamiste uurimissuundade hulka kuuluvad:

- Pärastjääegse kliima rekonstrueerimine eri analüüsimeetoditega;
- Pärastjääegse maakatte ja taimestiku rekonstrueerimine;
- Õietolmuandmete põhised ökoloogilised seosed ja paleomitmekesisus;
- Mineviku maakasutus ning ökosüsteemide kohanemine põllundusliku maakasutuse muutustega;
- Pärastjääegne jäätaande kronoloogia ja paleogeograafia;
- Läänemere varasemate staadiumite areng ning keskkonnaseisund.

Töörühmal on uurimistööks vajalik uurimiskeskond: puurimisvarustus, setteproovide külmhoidla, ettevalmistuslaborid proovide eeltöötlemiseks ning biogeokeemiline teadusaparatuurikompleks.

Lõppes Eesti Teadusagentuuri rahastatud projekt IUT1-8 "Pärastjääaja paleoökoloogia ja -kliima Balti regioonis", mille raames avaldati 2018 a WoS poolt tsiteeritud ajakirjades (ETIS kategooria 1.1) 20 teadusartiklit ning Merlin Liiv kaitses doktoritöö (Järvesetete orgaanilise aine süsiniku ja lämmastiku suhte kasutusvõimalused pärastjääegsete keskkonnamuutuste rekonstrueerimisel).

#### **Instituudi järel doktorite ning järel doktorantuuri suundunud instituudi töötajate loetelu:**

**Leeli Amon**, Holland, Utrecht Ülikool/ Saksamaa, GeoForschungsZentrum, Potsdam, 01.09.2017-04.02.2019, ETAG personaalse uurimistoetuse järel doktoritoetus

**Yan Liang**, TTÜ geoloogia instituut, 1.09.2017- 31.08.2019, ETAG Mobilias Plus järel doktoritoetus (juhendaja prof Olle Hints)

#### **Division of Quaternary Geology**

Head: Professor SIIM VESKI, [siim.veski@taltech.ee](mailto:siim.veski@taltech.ee)

Members: Tiiu Alliksaar, Atko Heinsalu, Anatoli Molodkov, Anneli Poska, Triin Reitalu, Jüri Vassiljev, Leeli Amon-Veskimeister

Doctoral students: Ansis Blaus, Mariliis Eensalu, Merlin Liiv, Vladimir Karpin

Keywords: postglacial climate change, human impact, paleodiversity

Quaternary geology, paleoecology and related research disciplines explaining the current paradigm of actualism in geology, have been one of the principal targets of research at the Department of Geology since the 1950s. At present, the research group comprises of seven researchers, one postdoc and four PhD students, who work in close collaboration as a targeted team, as well as with other groups in the department. We have fruitful collaboration worldwide, notably in US, Russia, Sweden, Finland, Canada, Germany, UK, Netherlands, Switzerland, Latvia, Lithuania and Belarus.

The main research aim of the Quaternary group is reconstruction of past ecosystems, vegetation history, climate and environmental change, both natural and manmade, at high temporal resolution during the last 15,000 years through multidisciplinary and multiproxy studies of natural archives such as lake, bog and marine sediments. The Quaternary is known for rapid climate change, glacial advances and retreats, constant drift of biota between glacial and warm refugia, sea level fall and rise with each period of freezing and thawing. It's also known as the period of the rise of mankind and its progressively increasing impact upon the environment. The group focusses on better understanding the interactions between Quaternary geo- and biosphere processes, in particular, addressing the following:

- Paleoclimate variation using multi-proxy analyses (such as pollen and chironomid based inference models);
- Paleobiodiversity (terrestrial and aquatic), functional and phylogenetic diversity dynamics and relationships with climate and environmental changes;
- Past human impact upon landscapes, waterbodies, vegetation structure and landcover;
- Postglacial retreat of the ice sheet;
- Shoreline displacement of the Baltic Sea.

The group holds leading position in Quaternary and palaeoecological studies in the Baltic realm. The main strengths of the group's work are related to the high-resolution paleo-datasets of geographically and climatically constrained area. Studies conducted at the department have been published in leading research journals including Nature Communications, Geology, QSR, Geobiology and Science of the Total Environment.

The group hosts several labs of biostratigraphy, dating, geochemistry, granulometry, and takes use of mass spectrometry lab for stable isotope geochemistry.

Main results: The institutional research project funded by Estonian Research Council (IUT1-8 "Postglacial paleoecology and paleoclimate in the Baltic area" ended, within this project **20** WoS cited journals papers (ETIS 1.1) were published in 2018. Merlin Liiv defended PhD dissertation (Application of Lake Sediment Carbon/Nitrogen Ratio in Post-Glacial Paleoenvironmental Reconstruction).

Major publications 2018:

- **Poska, A., Väli, V., Tomson, P., Vassiljev, J., Kihno, K., Alliksaar, T., Villoslada, M., Saarse, L., Sepp, K.** 2018. Reading past landscapes: combining modern and historical records, maps, pollen-based vegetation reconstructions, and the socioeconomic background. *Landscape Ecology* **33**, 529-546.
- **Liiv, M., Alliksaar, T., Freiberg, R., Heinsalu, A., Ott, I., Tõnno, I., Vassiljev, J., Veski, S.** 2018. Drastic changes in lake ecosystem development as a consequence of flax retting: a multiproxy palaeolimnological study of Lake Kooraste Linajärv, Estonia. *Vegetation History and Archaeobotany* **27**, 437-451.
- **Stivriņs, N., Soininen, J., Tõnno, I., Freiberg, R., Veski, S., Kisand, V.** 2018. Towards understanding the abundance of non-pollen palynomorphs: A comparison of fossil algae, algal pigments and *seda*DNA from temperate lake sediments. *Review of Palaeobotany and Palynology* **249**, 9-15.

## Geoloogia instituudi 2018. a teadusartiklid (1.1 kategooria):

- 1) Belle, S., Freiberg, R., **Poska**, A., Agasild, H., **Alliksaar**, T., Tönno, I. 2018. Contrasting responses to long-term climate change of carbon flows to benthic consumers in two different sized lakes in the Baltic area. *Quaternary Science Reviews* **187**, 168-176. Published online: 30. March 2018. DOI:10.1016/j.quascirev.2018.03.027 [WoS IF<sub>2017</sub> - 4.334; Rank<sub>2017</sub> - Q1]
- 2) Belle, S., Musazzi, S., Tönno, I., **Poska**, A., Leys, B., Lami, A. 2018. Long-term effects of climate change on carbon flows through benthic secondary production in small lakes. *Freshwater Biology* **63**, 530-538. Published online: 19. February 2018. DOI:10.1111/fwb.13090 [WoS IF<sub>2017</sub> - 3.767; Rank<sub>2017</sub> - Q1]
- 3) Belle, S., Tönno, I., **Stivrins**, N., **Veski**, S. 2018. Abrupt rise in the contribution of CH<sub>4</sub>-derived carbon to benthic secondary production of a shallow hemiboreal/boreal lake. *Journal of Quaternary Science* **33**, 969-976. Published online: 19. November 2018. DOI:10.1002/jqs.3075 [WoS IF<sub>2017</sub> - 2.324; Rank<sub>2017</sub> - Q2/Q3]
- 4) Birski, Ł., Wirth, R., Słaby, E., Wudarska, A., **Lepland**, A., Hofmann, A., Schreiber, A. 2018. (Ca-Y)-phosphate inclusions in apatite crystals from Archean rocks from the Barberton Greenstone Belt and Pilbara Craton: First report of natural occurrence. *American Mineralogist* **103**, 307-313. Published online: 29. January 2018. <https://doi.org/10.2138/am-2018-6150> [WoS IF<sub>2017</sub> - 2.645; Rank<sub>2017</sub> - Q2]
- 5) Bitinas, A., Dobrotin, N., Buynevich, I.V., **Molodkov**, A., Damušytė, A., Pupienis, D. 2018. Coastal dune dynamics along the northern Curonian Spit, Lithuania: toward an integrated database. *Geological Quarterly* **62**, 553-562. Published online: 25. October 2018. doi:10.7306/gq.1435 [WoS IF<sub>2017</sub> - 1.128; Rank<sub>2017</sub> - Q3]
- 6) Blättler, C.L., Claire, M.W., Prave, A.R., Kirsimäe, K., Higgins, J.A., Medvedev, P.V., Romashkin, A.E., Rychanchik, D.V., Zerkle, A.L., Paiste, K., Kreitsmann, T., Millar, I.L., Hayles, J.A., Bao, H., Turchyn, A.V., Warke, M.R., **Lepland**, A. 2018. Two-billion-year-old evaporites capture Earth's great oxidation. *Science* **360**, 320-323. Published online: 22. March 2018. <https://doi.org/10.1126/science.aar2687> [WoS IF<sub>2017</sub> - 41.058; Rank<sub>2017</sub> - Q1]
- 7) Cole, S.R., **Toom**, U. 2018. New camerate crinoid genera from the Upper Ordovician (Katian) of Estonia: evolutionary origin of family Opsicrinidae and a phylogenetic assessment of Ordovician Monobathrida. *Journal of Systematic Palaeontology* **xx**, xx-xx. Published online: 27. March 2018. <https://doi.org/10.1080/14772019.2018.1447519> [WoS IF<sub>2017</sub> - 2.326; Rank<sub>2017</sub> - Q1/Q3]
- 8) Crémière, A., Chand, S., Sahy, D., Thorsnes, T., **Martma**, T., Noble, S.R., Pedersen, J.H., Brunstad, H., **Lepland**, A., 2018. Structural controls on seepage of thermogenic and microbial methane since the last glacial maximum in the Harstad Basin, southwest Barents Sea. *Marine and Petroleum Geology* **98**, 569-581. Published online: 10. August 2018. <https://doi.org/10.1016/j.marpetgeo.2018.07.010> [WoS IF<sub>2017</sub> - 3.281; Rank<sub>2017</sub> - Q1]
- 9) Deev, E., Turova, I., Borodovskiy, A., Zolnikov, I., Pozdnyakova, N., **Molodkov**, A. 2018. Large earthquakes in the Katun Fault zone (Gorny Altai): Paleoseismological and archaeoseismological evidence. *Quaternary Science Reviews* **xx**, xx-xx. Published online: 19. November 2018. <https://doi.org/10.1016/j.quascirev.2018.11.009> [WoS IF<sub>2017</sub> - 4.334; Rank<sub>2017</sub> - Q1]
- 10) Dengler, J., Wagner, V., Dembicz, I., García-Mijangos, I., Naqinezhad, A., Boch, S., Chiarucci, A., Conradi, T., Filibeck, G., Guarino, R., Janišová, M., Steinbauer, M.J., Ačić, S., Acosta, A.T.R., Akasaka, M., Allers, M.-A., Apostolova, I., Axmanová, I., Bakan, B., Baranova, A., Bardy-Durchhalter, M., Bartha, S., Baumann, E., Becker, T., Becker, U., Belonovskaya, E., Bengtsson, K., Alonso, J.L.B., Berastegi, A., Bergamini, A., Bonini, I., Bruun, H.H., Budzhak, V., Bueno, A., Campos, J.A., Cancellieri, L., Carboni, M., Chocarro, C., Conti, L., Czarniecka-Wiera, M., De Frenne, P., Deák, B., Didukh, Y.P., Diekmann, M., Dolnik, C., Dupré, C., Ecker, K., Ermakov, N., Erschbamer, B., Escudero, A., Etayo, J., Fajmonová, Z., Felde, V.A., Fernández Calzado, M.R., Finckh, M., Fotiadis, G., Fracchiolla, M., Ganeva, A., García-Magro, D., Gavilán R.G., Germany, M., Giladi, I., Gillet, F., Giusso del Galdo, G.P., González, J.M., Grytnes, J.-A., Hájek, M., Hájková, P., Helm, A., Herrera, M., Hettnerbergerová, E., Hobohm, C., Hüllbusch, E.M., Ingerpuu, N., Jandt, U., Jeltsch, F., Jensen, K., Jentsch, A., Jeschke, M., Jiménez-Alfaro, B., Kaçki, Z., Kakinuma, K., Kapfer, J., Kavgacı, A., Kelemen, A., Kiehl, K., Koyama, A., Koyanagi, T.F., Kozub, Ł., Kuzemko, A., Kyrkjeeide, M.O., Landi, S., Langer, N., Lastrucci, L., Lazzaro, L., Lelli, C., Lepš, J., Löbel, S., Luzuriaga, A.L., Maccherini, S., Magnes, M., Malicki, M., Marcenò, C.,

Mardari, C., Mauchamp, L., May, F., Michelsen, O., Mesa, J.M., Molnár, Z., Moysiyenko, I.Y., Nakaga, Y.K., Natcheva, R., Noroozi, J., Pakeman, R.J., Palpurina, S., Pärtel, M., Pätzsch, R., Pauli, H., Pedashenko, H., Peet, R.K., Pielech, R., Pipenbahr, N., Pirini, C., Plesková, Z., Polyakova, M.A., Prentice, H.C., Reinecke, J., **Reitalu**, T., Rodríguez-Rojo, M.P., Roleček, J., Ronkin, V., Rosati, L., Rosén, E., Ruprecht, E., Rusina, S., Sabovljević, M., Sánchez, A.M., Savchenko, G., Schuhmacher, Škornik, O.S., Sperandii, M.G., Staniaszek-Kik, M., Stevanović-Dajić, Z., Stock, M., Suchrow, S., Sutcliffe, L.M.E., Swacha, G., Sykes, M., Szabó, A., Talebi, A., Tănase, C., Terzi, M., Tölgyesi, C., Torca, M., Török, P., Tóthmérész, B., Tsarevskaya, N., Tsiripidis, I., Tzonev, R., Ushimaru, A., Valkó, O., van der Maarel, E., Vanneste, T., Vashenyak, I., Vassilev, K., Viciani, D., Villar, L., Virtanen, R., Vitasović Kosić, I., Wang, Y., Weiser, F., Went, J., Wesche, K., White, H., Winkler, M., Zaniewski, P.T., Zhang, H., Ziv, Y., Znamenskiy, S., Biurrun, I. 2018. GrassPlot – a database of multi-scale plant diversity in Palearctic grasslands. *Phytocoenologia* **48**, 331-347. Published online: 24. May 2018. DOI:10.1127/phyto/2018/0267 [WoS IF<sub>2017</sub> - 1.721; Rank<sub>2017</sub> – Q2/Q3]

11) Dietze, E., Theuerkauf, M., Bloom, K., Brauer, A., Dörfler, W., Feeser, I., Feurdean, A., Gedminienė, L., Giesecke, T., Jahns, S., Karpińska-Kończak, M., Kończak, P., Lamentowicz, M., Latałowa, M., Marcisz, K., Obremaska, M., Pędziszewska, A., **Poska**, A., Rehfeld, K., Stančikaitė, M., **Stivrins**, N., Święta-Musznicka, J., Szal, M., **Vassiljev**, J., **Veski**, S., Wacnik, A., Weisbrodt, D., Wiethold, J., Vannièrè, B., Słowiński, M. 2018. Holocene fire activity during low-natural flammability periods reveals scale-dependent cultural human-fire relationships in Europe. *Quaternary Science Reviews* **201**, 44-56. Published online: 20. October 2018. <https://doi.org/10.1016/j.quascirev.2018.10.005> [WoS IF<sub>2017</sub> - 4.334; Rank<sub>2017</sub> - Q1]

12) Giesecke, T., Kuneš, P., **Reitalu**, T. 2018. Millennial to centennial vegetation change. *Journal of Vegetation Science* **29**, 357-359. Published online: 19. May 2018. <https://doi.org/10.1111/jvs.12650> [WoS IF<sub>2017</sub> - 2.658; Rank<sub>2017</sub> - Q1/Q2]

13) **Hints**, L., Harper, D.A.T., Paškevičius, J. 2018. Diversity and biostratigraphic utility of Ordovician brachiopods in the East Baltic. *Estonian Journal of Earth Sciences* **67**, 176-191. <https://doi.org/10.3176/earth.2018.14> [WoS IF<sub>2017</sub> - 0.927; Rank<sub>2017</sub> - Q4]

14) **Hints**, O. 2018. Towards a better understanding of the Palaeozoic world. *Estonian Journal of Earth Sciences* **67**, 226-227. <https://doi.org/10.3176/earth.2018.22> [WoS IF<sub>2017</sub> - 0.927; Rank<sub>2017</sub> - Q4]

15) **Hints**, O., **Antonovits**, L., **Bauert**, G., Nestor, V., **Nölvak**, J., Tammekänd, M. 2018. CHITDB: a database for documenting and analysing diversification of Ordovician–Silurian chitinozoans in the Baltic region. *Lethaia* **51**, 218-227. Published online: 12. October 2017. DOI:10.1111/let.12249 [WoS IF<sub>2017</sub> - 2.218; Rank<sub>2017</sub> - Q1]

16) **Hitch**, M., Lytle, M., Tost, M. 2018. Social licence: power imbalances and levels of consciousness – two case studies. *International Journal of Mining, Reclamation and Environment* **xx**, xx-xx. Published online: 05. December 2018. DOI:10.1080/17480930.2018.1530582 [WoS IF<sub>2017</sub> - 1.258; Rank<sub>2017</sub> - Q3]

17) Jöngiste, K., Frelich, L.E., Laarmann, D., Vodde, F., Baders, E., Donis, J., Jansons, A., Kangur, A., Korjus, H., Köster, K., Kusmin, J., Kuuluvainen, T., Marozas, V., Metslaid, M., Metslaid, S., Polyachenko, O., **Poska**, A., Rebane, S., Stanturf, J.A. 2018. Imprints of management history on hemiboreal forest ecosystems in the Baltic States. *Ecosphere* **9**, e02503. Published online: 15. November 2018. <https://doi.org/10.1002/ecs2.2503> [WoS IF<sub>2017</sub> - 2.671; Rank<sub>2017</sub> - Q2]

18) Kalińska-Nartiša, E., **Stivrins**, N., Grudzinska, I. 2018. Quartz grains reveal sedimentary palaeoenvironment and past storm events: A case study from eastern Baltic. *Estuarine, Coastal and Shelf Science* **200**, 359-370. Published online: 28. November 2017. <https://doi.org/10.1016/j.ecss.2017.11.027> [WoS IF<sub>2017</sub> - 2.413; Rank<sub>2017</sub> - Q1]

19) **Kaljo**, D. 2018. Twelve years of the *Estonian Journal of Earth Sciences*: a survey of achievements and their bearing on Earth sciences in Estonia. *Estonian Journal of Earth Sciences* **67**, 223-224. <https://doi.org/10.3176/earth.2018.21> [WoS IF<sub>2017</sub> - 0.927; Rank<sub>2017</sub> - Q4]

20) Kisand, V., Talas, L., Kisand, A., **Stivrins**, N., **Reitalu**, T., **Alliksaar**, T., **Vassiljev**, J., **Liiv**, M., **Heinsalu**, A., Seppä, H., **Veski**, S. 2018. From microbial eukaryotes to metazoan vertebrates: wide spectrum paleo-

diversity in sedimentary ancient DNA over the last ~14,500 years. *Geobiology* **16**, 628-639. Published online: 23. July 2018. DOI:10.1111/gbi.12307 [WoS IF<sub>2017</sub> - 4.158; Rank<sub>2017</sub> - Q1]

21) Korsakova, O., **Molodkov**, A., Yelovicheva, Y., Kolka, V. 2018. Middle Pleistocene marine deposits on the Kola Peninsula (NW Russia). *Quaternary International* **xx**, xx-xx. Published online: 16. September 2018. <https://doi.org/10.1016/j.quaint.2018.09.019> [WoS IF<sub>2017</sub> - 2.163; Rank<sub>2017</sub> - Q2/Q3]

22) Kriiska, A., Oras, E., Nirgi, T., Shanskiy, M., **Heinsalu**, A., Vanhanen, S., Luoto, T.P. 2018. Environmental studies at the Kohtla-Vanaküla Iron Age sacrificial site, North-East Estonia. *Estonian Journal of Archaeology* **22**, 66-79. <https://doi.org/10.3176/arch.2018.1.05>

23) Kuosmanen, N., Marquer, L., Tallavaara, M., Molinari, C., Zhang, Y., Alenius, T., Edinborough, K., Pesonen, P., **Reitalu**, T., Renssen, H., Trondman A.-K., Seppä, H. 2018. The role of climate, forest fires and human population size in Holocene vegetation dynamics in Fennoscandia. *Journal of Vegetation Science* **29**, 382-392. Published online: 17. February 2018. DOI:10.1111/jvs.12601 [WoS IF<sub>2017</sub> - 2.658; Rank<sub>2017</sub> - Q1/Q2]

24) Lefebvre, B., Gutiérrez-Marco J.C., **Lehnert**, O., Martin E.L.O., Nowak H., Akodad M., El Hariri K., Servais T. 2018. Age calibration of the Lower Ordovician Fezouata Lagerstätte, Morocco. *Lethaia* **51**, 296-311. Published online: 19. September 2017. <https://doi.org/10.1111/let.12240> [WoS IF<sub>2017</sub> - 2.218; Rank<sub>2017</sub> - Q1]

25) Lepane, V., Künnis-Beres, K., **Kaup**, E., Sharma, B. 2018. Dissolved organic matter, nutrients, and bacteria in Antarctic soil core from Schirmacher Oasis. *Journal of Soils and Sediments* **18**, 2715-2726. Published online: 20. January 2018. <https://doi.org/10.1007/s11368-018-1913-7> [WoS IF<sub>2017</sub> - 2.627; Rank<sub>2017</sub> - Q2]

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