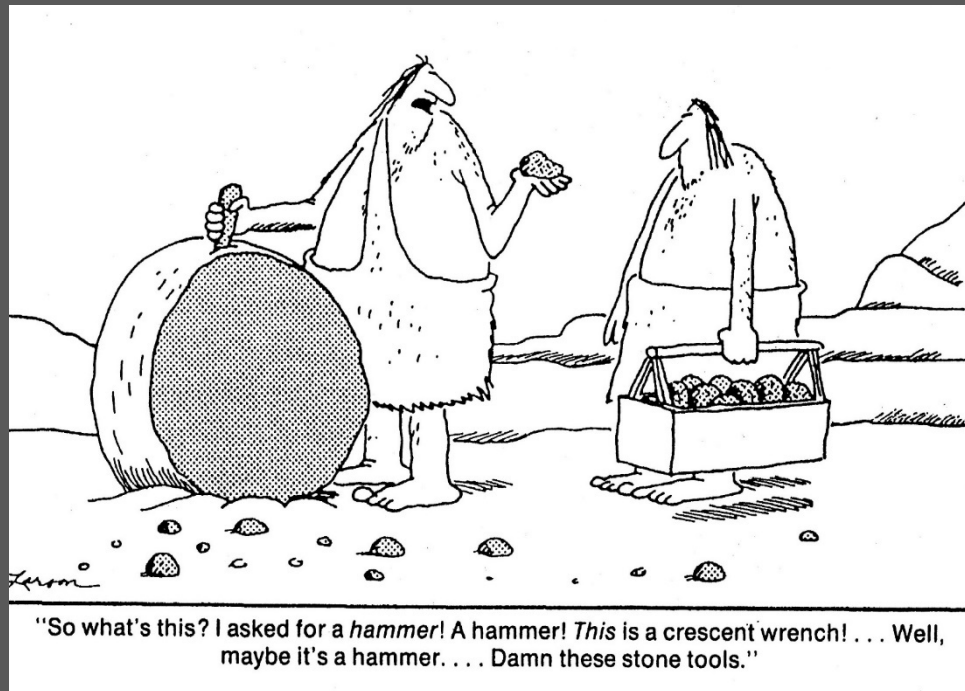


# Identifying Function

Problem: How to identify stone tools and their uses?



Solution: Microscopic Analysis



# Identifying Function

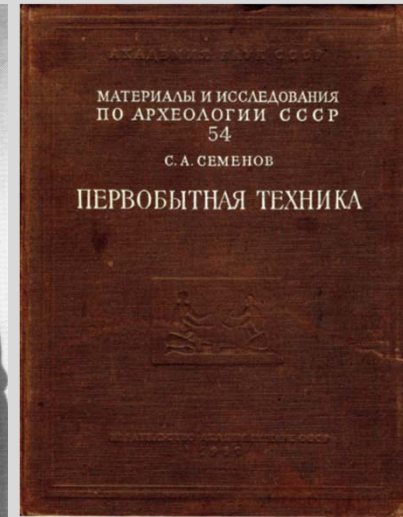
- Production of a tool is just a preparatory step for its use
- For the user, the techniques of manufacturing of the tools might be even irrelevant
- Therefore, the production technology of stone tools does not necessarily reflect user capabilities, behavioral capacities and intentions
- Identification of tool use through experimental framework, ethnographic data and the aid of microscopes
- **Traceology!**





# Prehistoric Technology

## Sergej A. Semenov



Sergej A. Semenov in 'Prehistoric Technology' 1957 (engl. 1964):

“... what distinguishes human history from natural history is that the first is made by us while the second is not. Technology reveals the active relationship between man and nature, a direct process of his existence, consequently of the social relationships of his life and so of the spiritual phenomena that arise from them.”



# Prehistoric Technology

## Sergej A. Semenov

- Microscopic analysis of lithic artefacts and their wear traces to determine their former use and function.
- Change of definition: Not only modified objects but all artefacts with traces of use must be considered as *Tools*.



However:

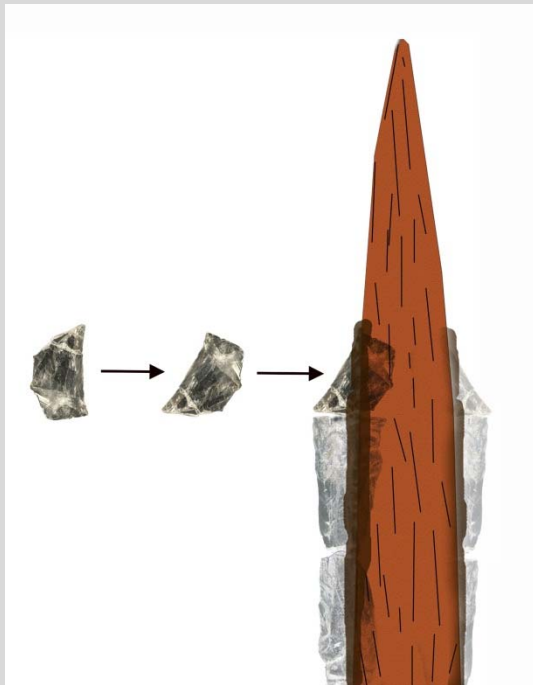
*“...microwear analysis is not for the dilettante. The techniques of examination are time consuming and demand attention to technical details, and the methodology behind any good microwear study must be specially constructed and carefully implemented.”*

Lawrence Keeley 1974: Technique and Methodology in Microwear Studies, p.334

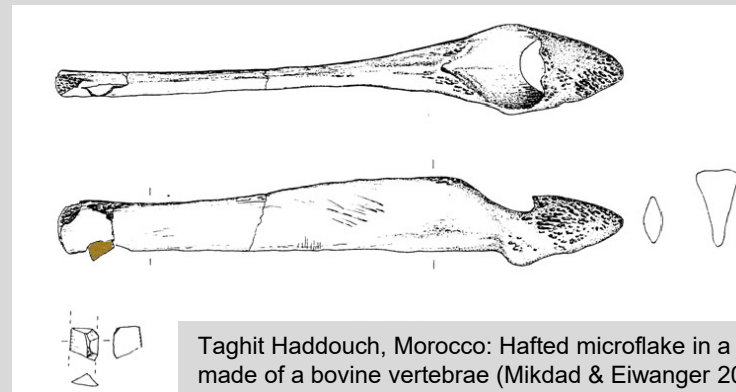
# New Perspectives



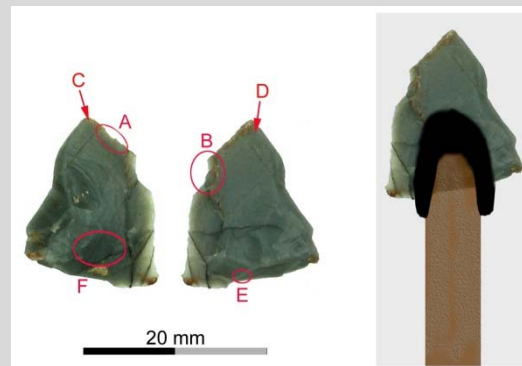
**Keeley 1982: Aspects of Hafting:** A “stone tool” is often just an implement and part of a composite tool of unknown form.



Ullafelsen, Austria: Reconstructed function of Mesolithic implements through microwear analysis (Pawlik, in Schäfer 2012)



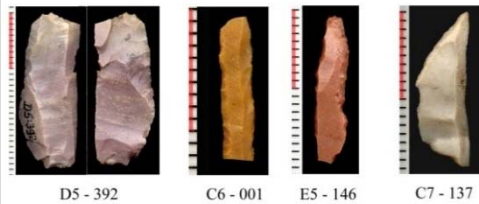
Taghit Haddouch, Morocco: Hafted microflake in a handle made of a bovine vertebrae (Mikdad & Eiwanger 2000)



Ille Cave, Philippines: Unretouched and irregularly shaped flake hafted and used as a projectile point (Pawlik 2012)

# Identification of Hafting

- Hafting wear traces
- Residues from adhesives

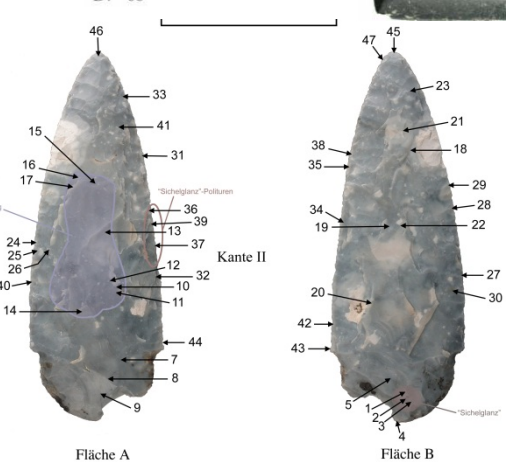
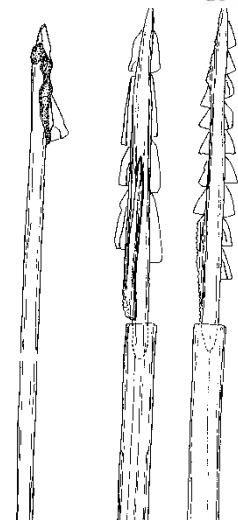
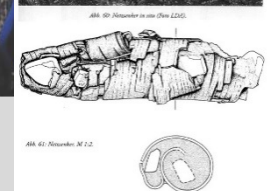
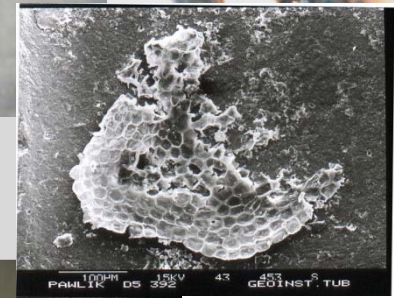
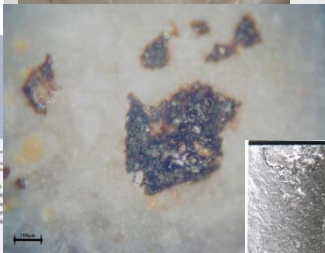
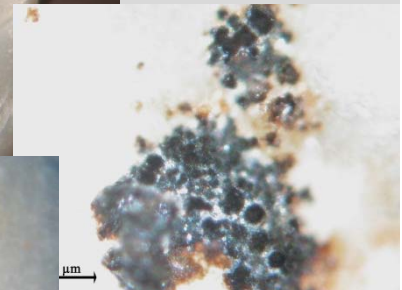
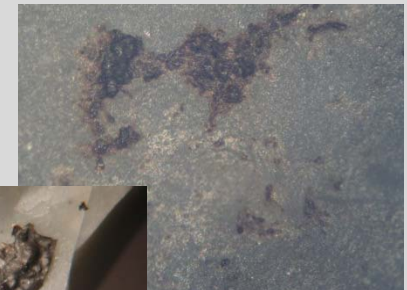


50 mm



## Der Dolch von Allensbach Spurensuche

Mit seiner perfekt geformten Klinge und dem erhaltenen Holzgriff ist der Allensbacher Dolch ein einzigartiges Fundstück. Bei fast allen übrigen Dolchlingen sind die aus organischen Materialien bestehenden Griffe vollständig vergangen. Die detaillierte Analyse von Klinge und Schaft verrät spannende Details über die Geschichte dieses bemerkenswerten Objektes.





# Principle of Traceology

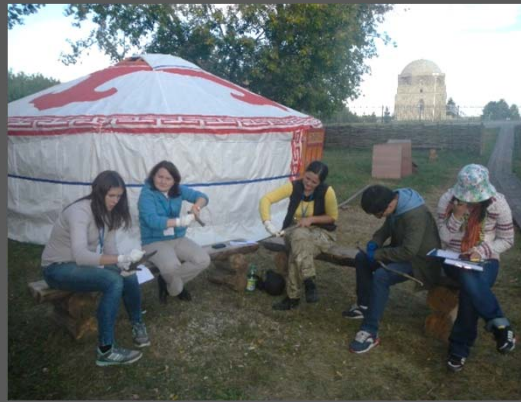


# Experimentation in Use-wear Studies

Pre-requisite for traceological analysis of archaeological material:

Experimental replication of prehistoric tasks and the detailed recording of activities

Use-wear analysis of experimental wear traces for referential data pool



# Functional Studies at ASP

University of the Philippines:  
Lithic Studies Laboratory of the  
Archaeological Studies Program,  
officially inaugurated in 2002.

- High Power and Low Power Analysis
- Lithic artefacts, shell and bone tools and cutmarks on bone are analysed.





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LSL I  
2002



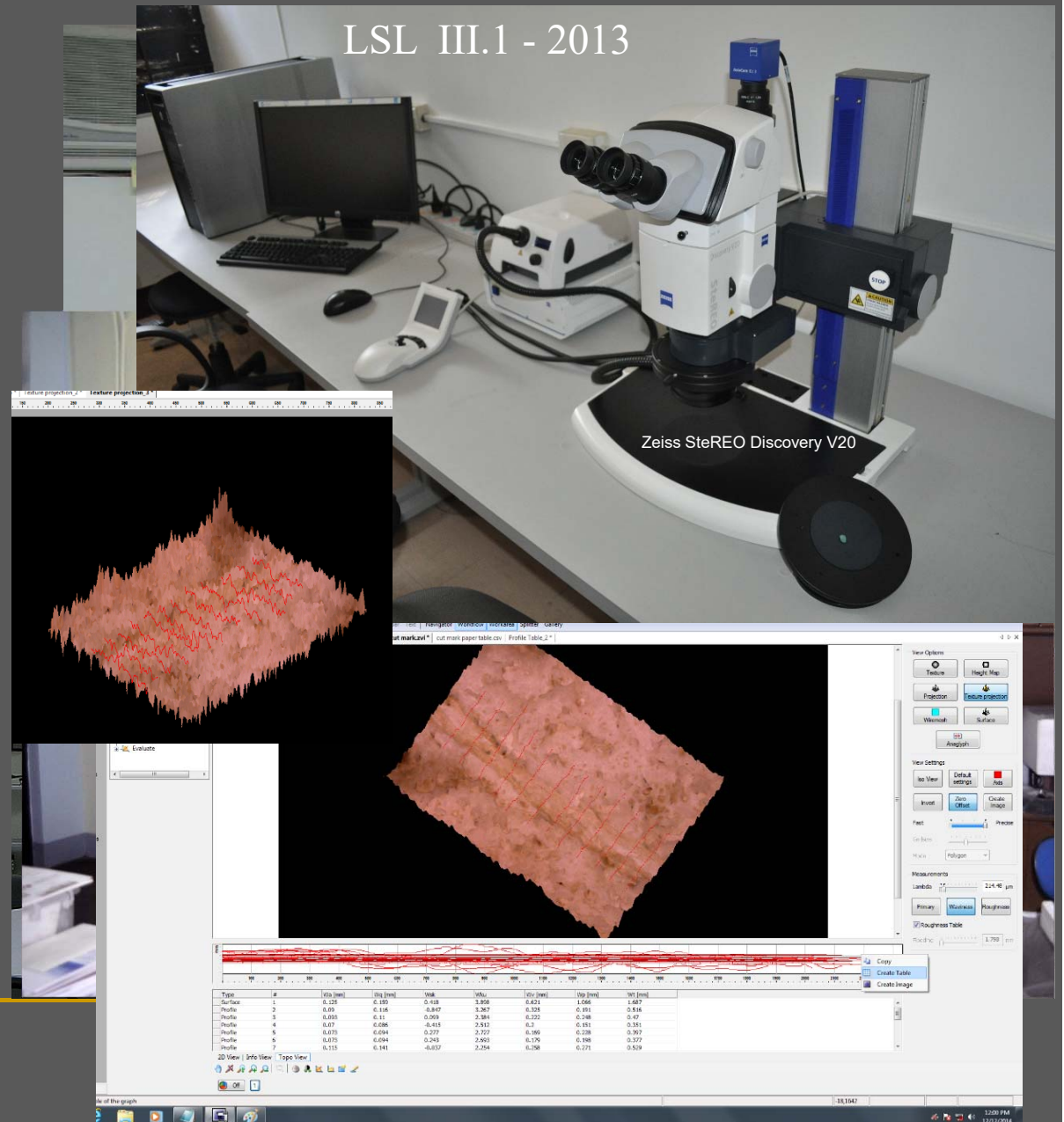
LSL III - 2011

# Functional Studies at ASP

University of the Philippines:  
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Archaeological Studies Program,  
officially inaugurated in 2002.

- High Power and Low Power Analysis
- Lithic artefacts, shell and bone tools and cutmarks on bone are analysed.
- Zeiss SteREO Discovery V20 Digital Microscopy Workstation and Axiovision software suite: Image analysis in 2D and 3D

LSL III.1 - 2013



<http://asp.upd.edu.ph>

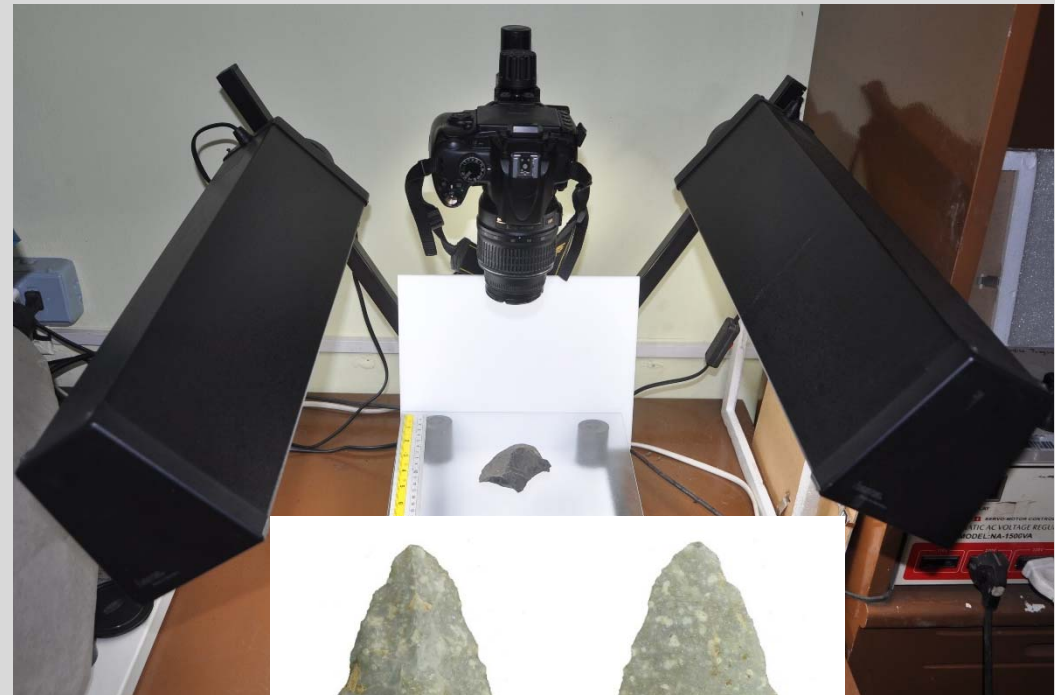
# Preparation for Use-wear Analysis

## Object Photography

- Digital camera
- Camera copy stand
- Neutral illumination
- Scale bar

## Accessories:

- Anti-reflex (frosted) glass top
- Dark velvet cloth
- Plasticine / molding clay
- White carton (light up)



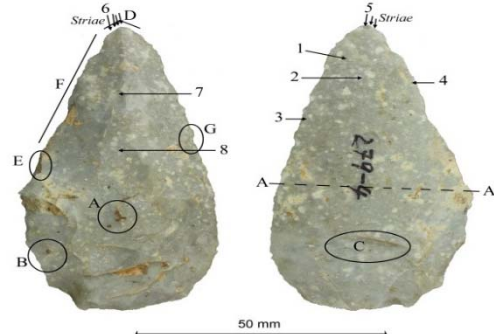
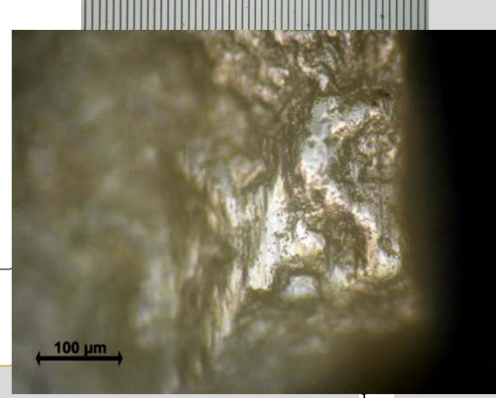


# Preparation for Use-wear Analysis

## Protocol sheet

- Mark position of wear traces
- Record microphotos
  - Numbering
  - Description
  - Magnification: Scale calibration
- Cleaning prior to analysis
  - Ultrasonic tank



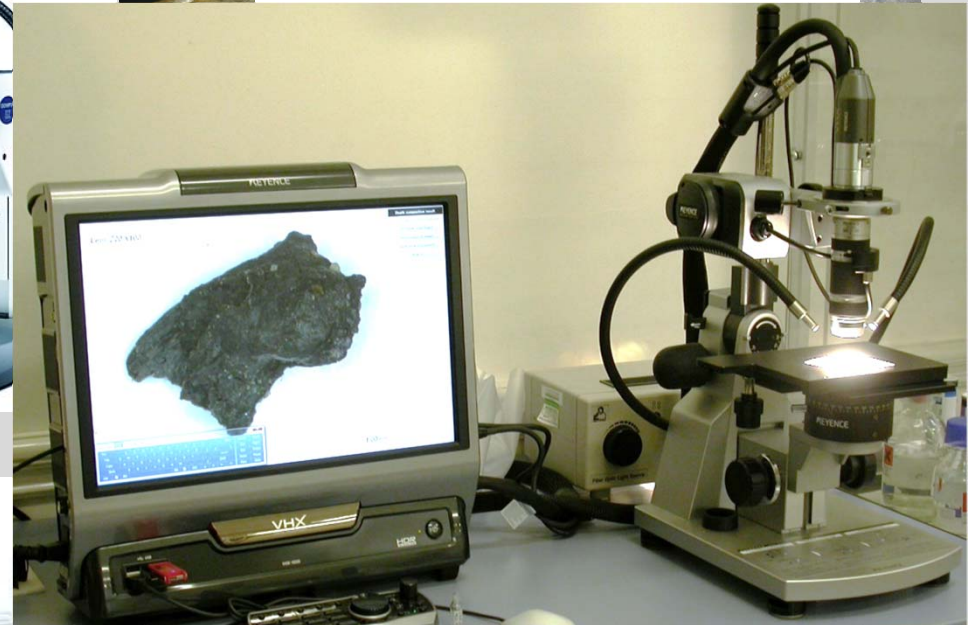
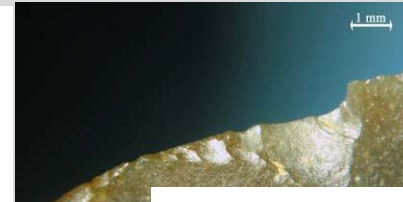
Object number: 279-4	Project: <b>Inden - Weisweiler</b>	Level 1	Leve 2	Leve 3
Date: _____				
Low Power Analysis:				
High Power Analysis:				
Comments:				

# Microscopic Use-wear Analysis

## “Low Power” Analysis

### Stereomicroscopes

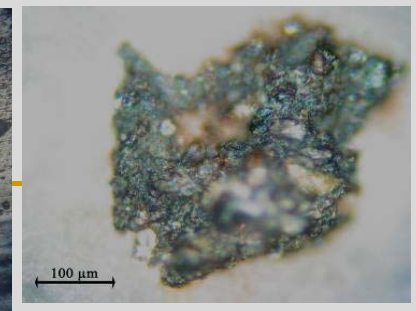
- Edge damage
- Abrasions
- Scarring
- Breaks
- Residues



## “High Power” Analysis

### Reflected light microscopes (LWD, DIC)

- Micropolishes
- Striations
- Residues

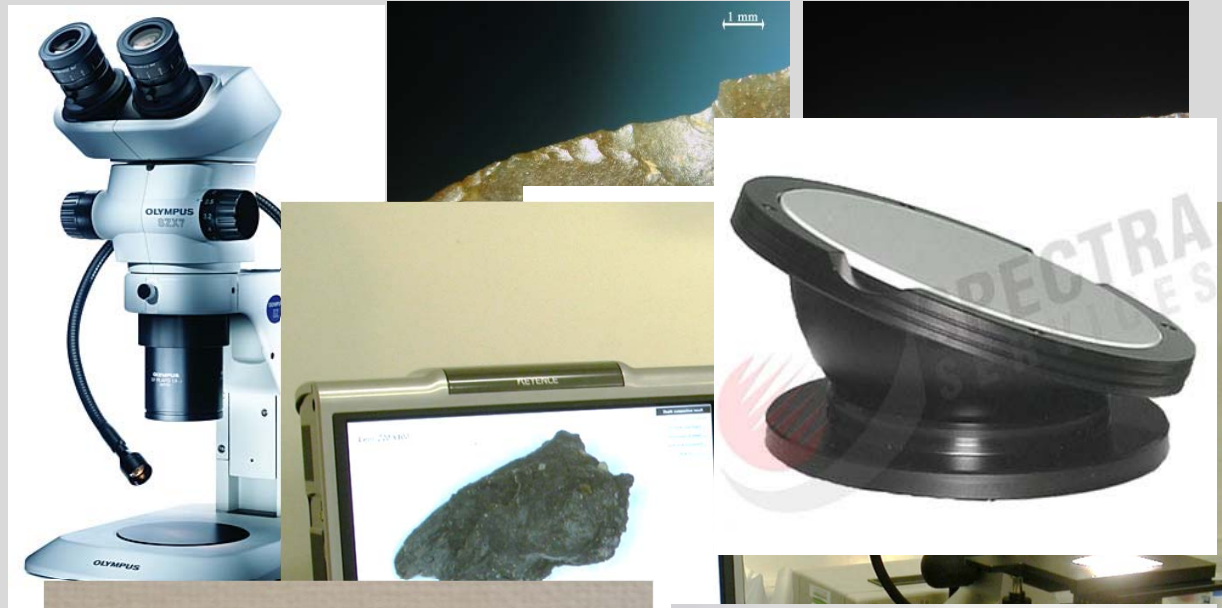


# Microscopic Use-wear Analysis

## “Low Power” Analysis

### Stereomicroscopes

- Edge damage
- Abrasions
- Scarring
- Breaks
- Residues



## “High Power” Analysis

### Reflected light microscopes (LWD, DIC)

- Micropolishes
- Striations
- Residues

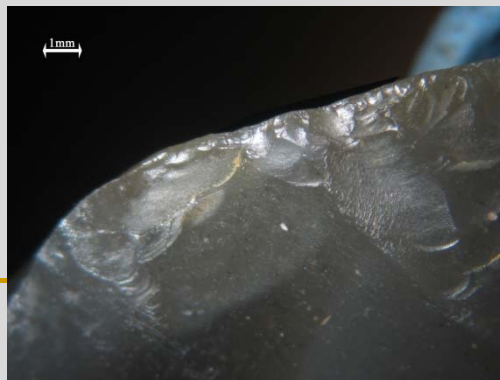
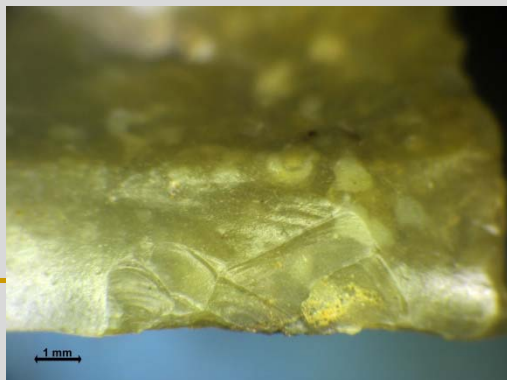
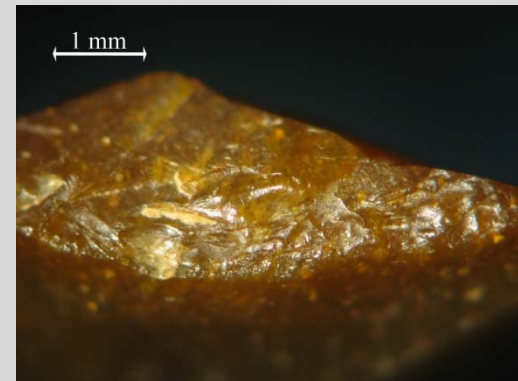
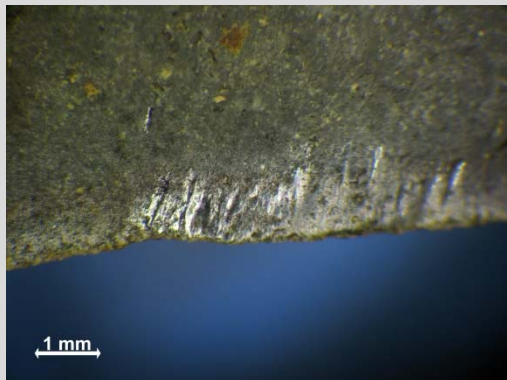
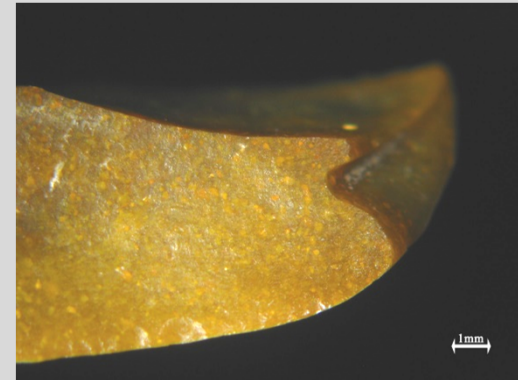


**Spherical object stage  
“cup stage”**

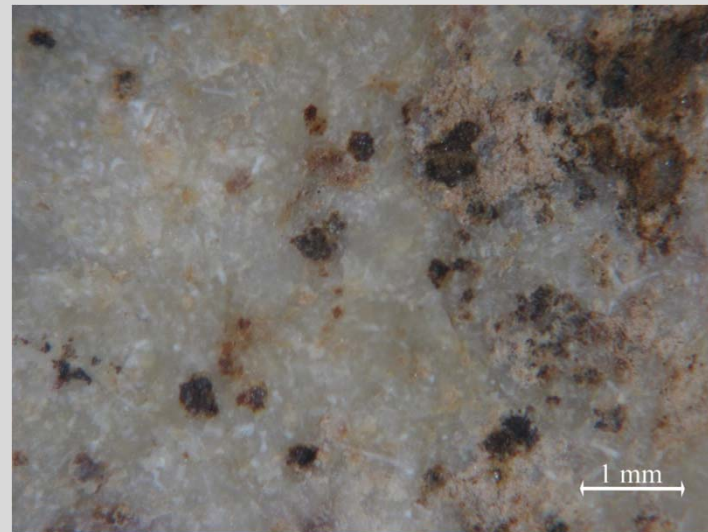
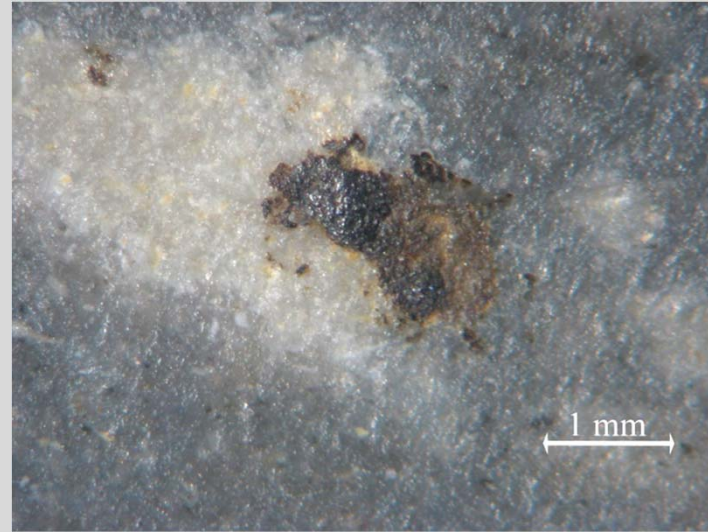
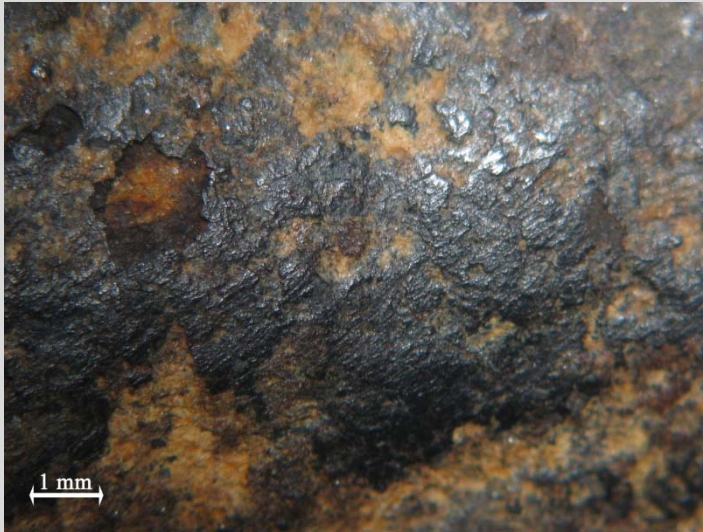




## Low Power Analysis: Wear and Tear

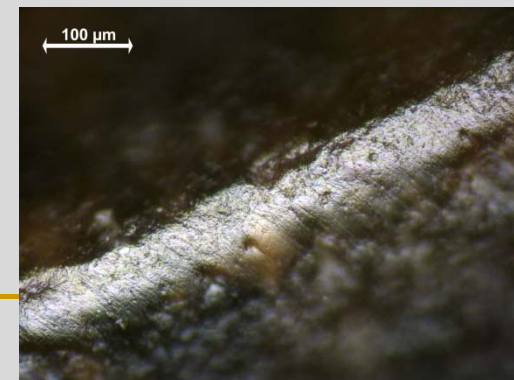
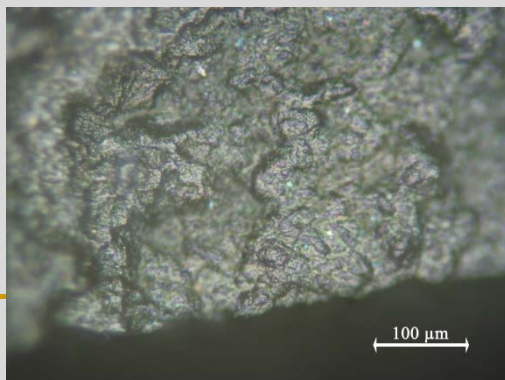
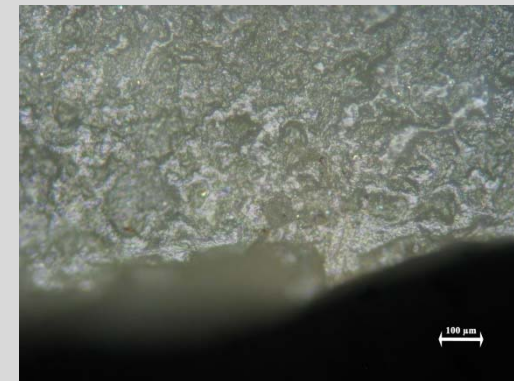
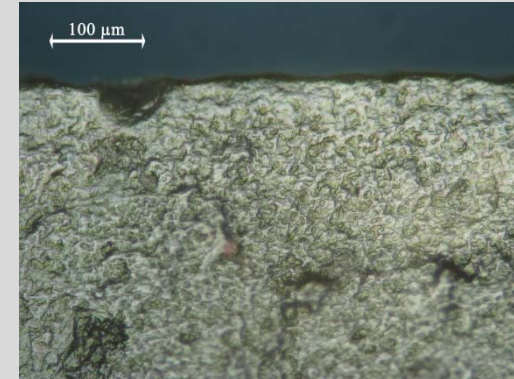
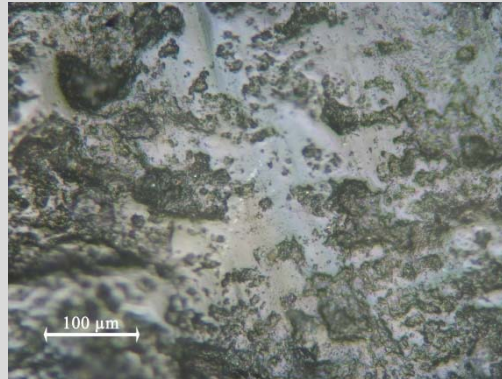
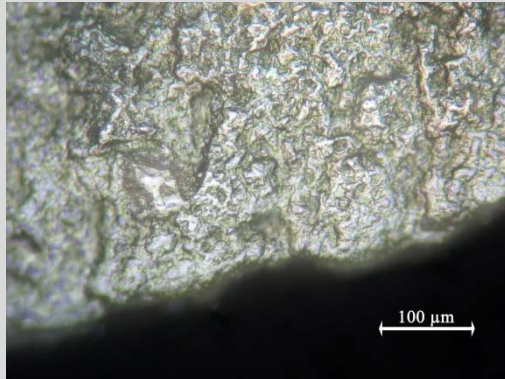


## Low Power Analysis: Hafting residues



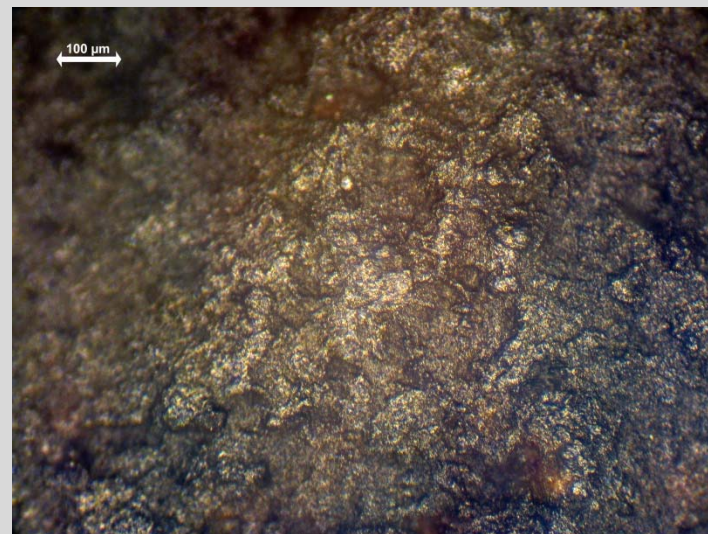
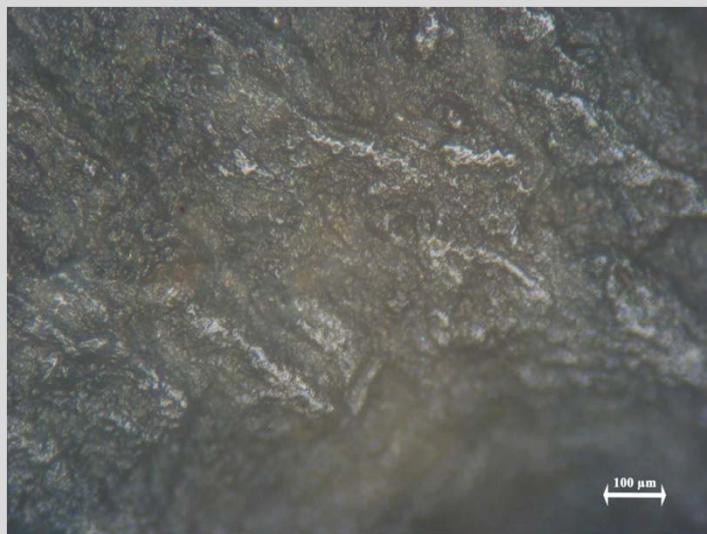
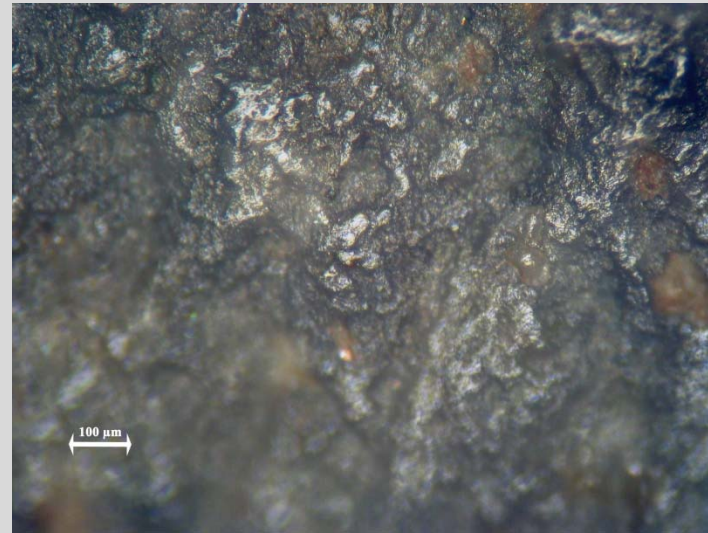
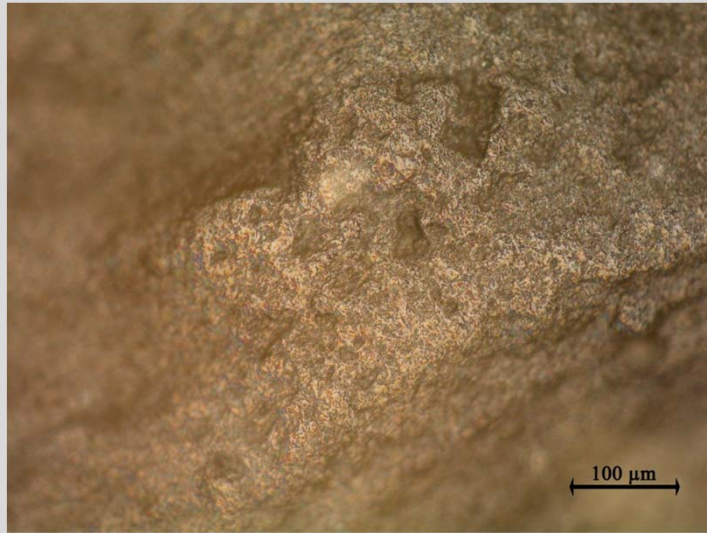


## High Power Analysis: Micropolishes



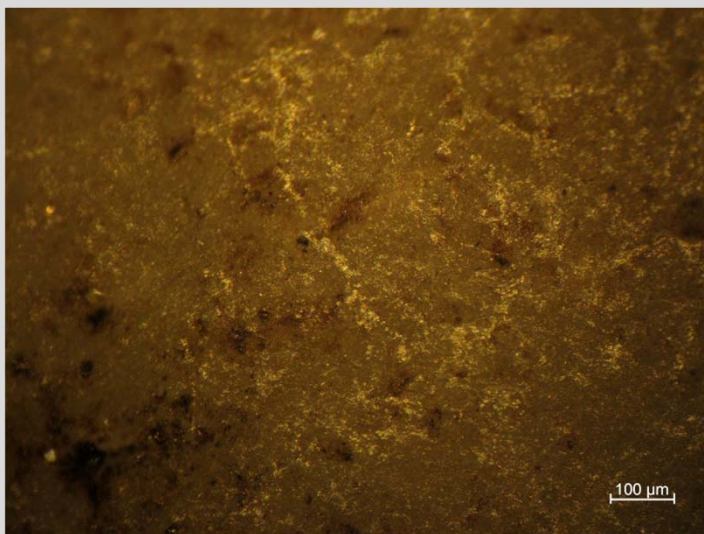


## High Power Analysis: Micropolish caused by interaction with a haft





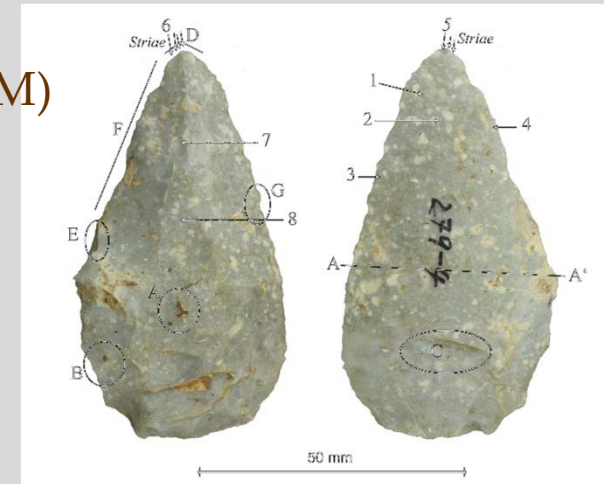
## Hafting polish associated with residues



# Microscopic Use-wear Analysis

## ■ Documentation and evaluation of the observed microwear features

- Use-wear / Non use-wear / Contamination
- Post-depositional surface modifications (PDSM)
- Qualitative: Verbal description of the morphology of all observed traces
- Quantitative: Use of attribute system and statistical analysis
- Visual: Microphotographic documentation



## ■ Data processing

- Database
- Text processor
- Image/video capture
- Image editing, enhancement
- Image analysis 2D/3D

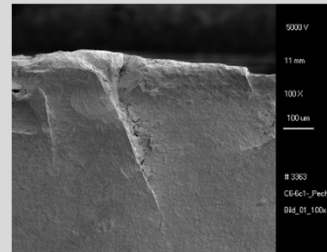
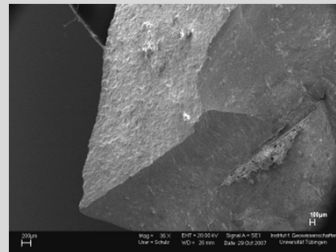
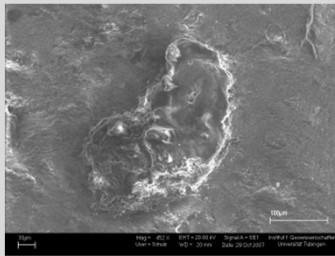
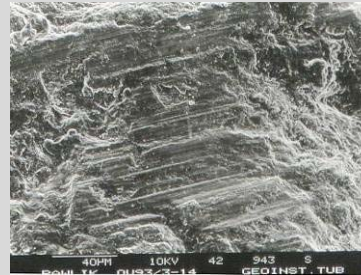




# Scanning electron microscopes in use-wear analysis

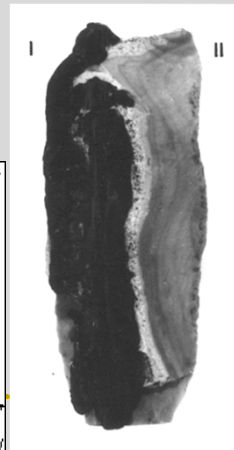
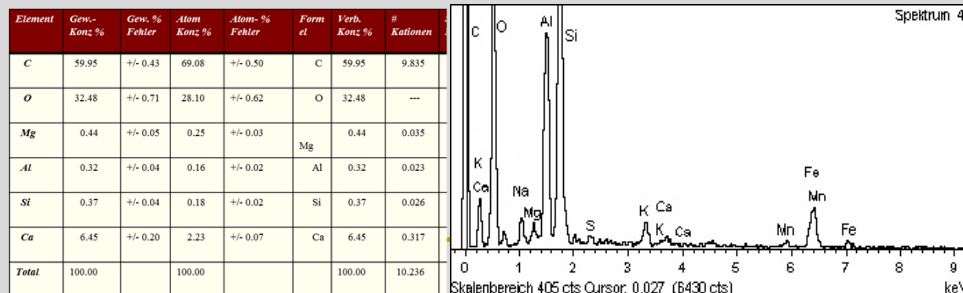
## Scanning electron microscopes

- + High magnifications
- + High depth of focus
- + Residues
- Not suitable for larger sample sizes
- Time consuming and high maintenance

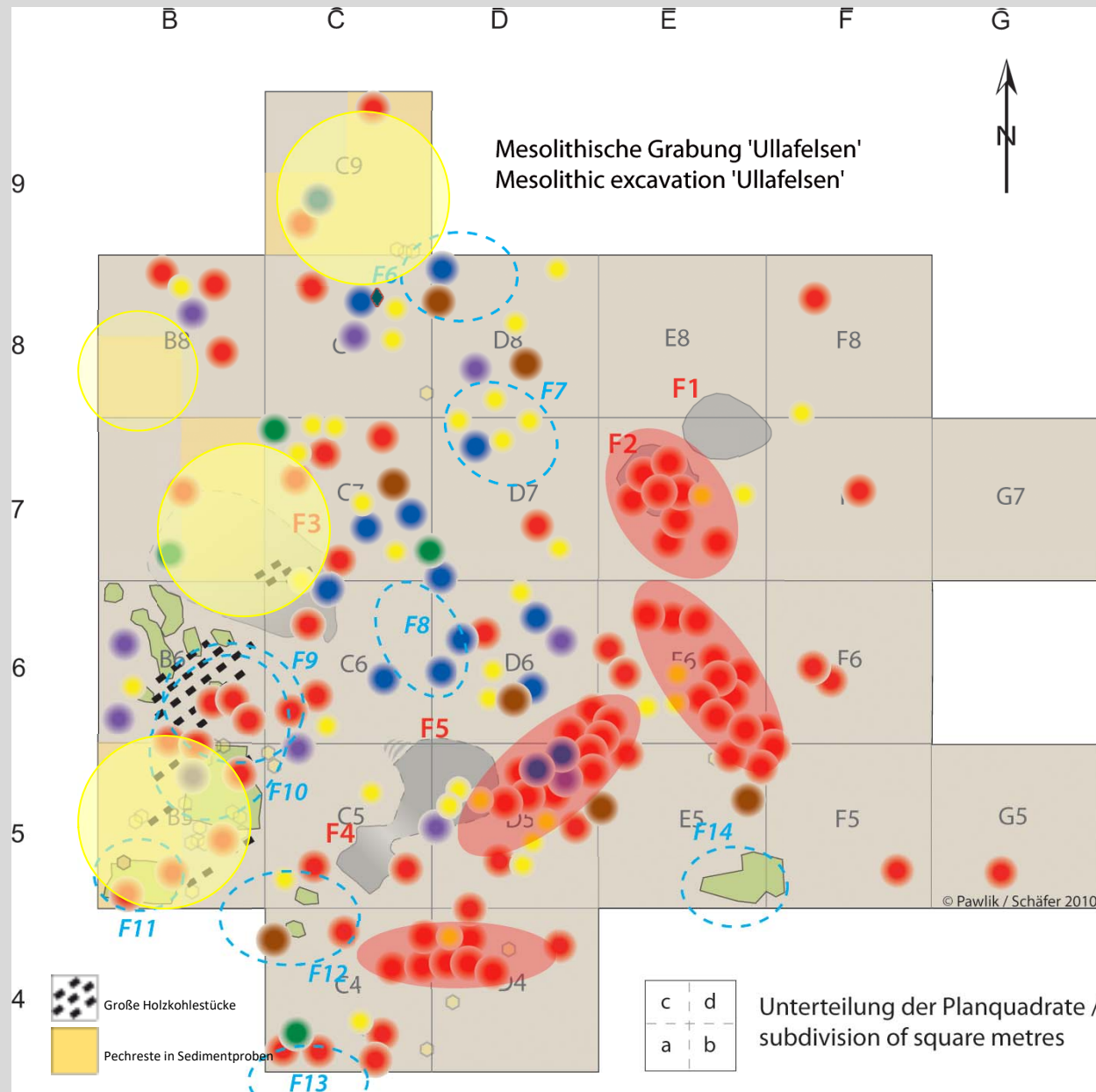


## Energy-dispersive Analysis of X-Rays (EDX)

- + Elementary signature of a sample
- + Identification of residues



# Mapping Function (if finds have recorded 3-D coordinates)



- Reparatur von Jagdwaffen  
Hafting-and-retooling
- Bearbeitung von Fell und Leder  
Hide and leather working
- Gebrauch, ohne nähere Bestimmung  
Used, w/o further specification
- Bearbeitung harter Materialien allg.  
Working of unspec. harder materials
- Bearbeitung von Knochen oder Geweih  
Working of bone or antler
- Bearbeitung von Holz  
Woodworking

## Identified:

- Maintenance of hunting weapons
- Manufacture / Repair of equipment
- Hafting-and-retooling zones are different from manufacture areas
- Processing of birch bark inside the camp. Fireplaces set up for the production of birch tar.

***Reconstruction of on-site activities and site function!***

# Microscopic Use-wear Analysis

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Microwear analysis offers:

- Actual technical and functional characterizations of lithic artefacts

- Identification of working / hunting tools

- Identification of worked materials

- Determination of activities and site functions

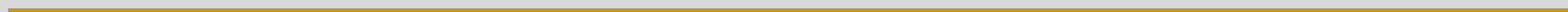
- Regionally and chronologically independent

- Potential for the detection of complex, “modern” technologies like hafting and composite tool making

- Contributes to the research on human behavior, technological and cognitive advancement!

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# Behavioural and Technological Complexity in the Middle Palaeolithic of Central Europe

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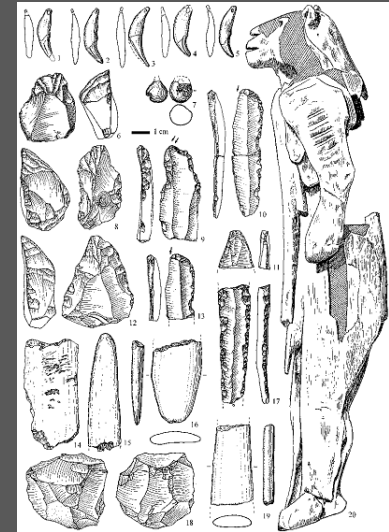


# Behavioural modernity: European origins

Assumption of a cultural/symbolic 'revolution' 40,000 years ago.

Indicators: Technical innovations like specialized blade industries, microliths, hafting technology, bone and antler tools, symbolic art, musical instruments and personal ornaments, etc. The 'Modern Package'

Aim: distinction of Neandertal and Homo sapiens capacities to explain the success of the late migrants.

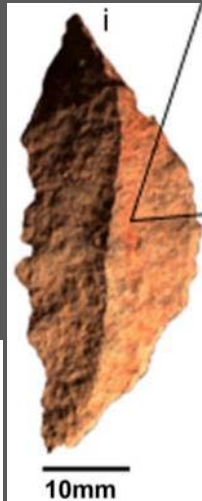
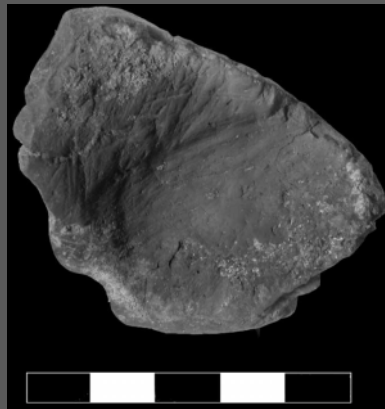


(Jensen, University of Tübingen; Johanson & Edgar 1996, Conard & Bolus 2003)



# Behavioural modernity independent from species?

Did *Homo sapiens* really come with a “package”?  
Parallel developments of at least some traits inside and outside Europe



Pigment use, personal ornaments, and micro tools from *Homo sapiens* sites Qafzeh, Es-Skhul / Israel, Oued Djebbana / Algeria, Sibudu Cave / South Afrika (Hovers et al. 2003; Vanhaeren 2006)



Pigment use, personal ornaments, micro tools and grinding stones from Neandertal sites Pech de l'Azé and Quinçay / France, Neandertal and Altdorf / Germany (Soressi 2007; Schmitz 2003, Thissen 2007, Pawlik & Thissen 2011, Pawlik 2011)

# Re-discovering Neandertal Man

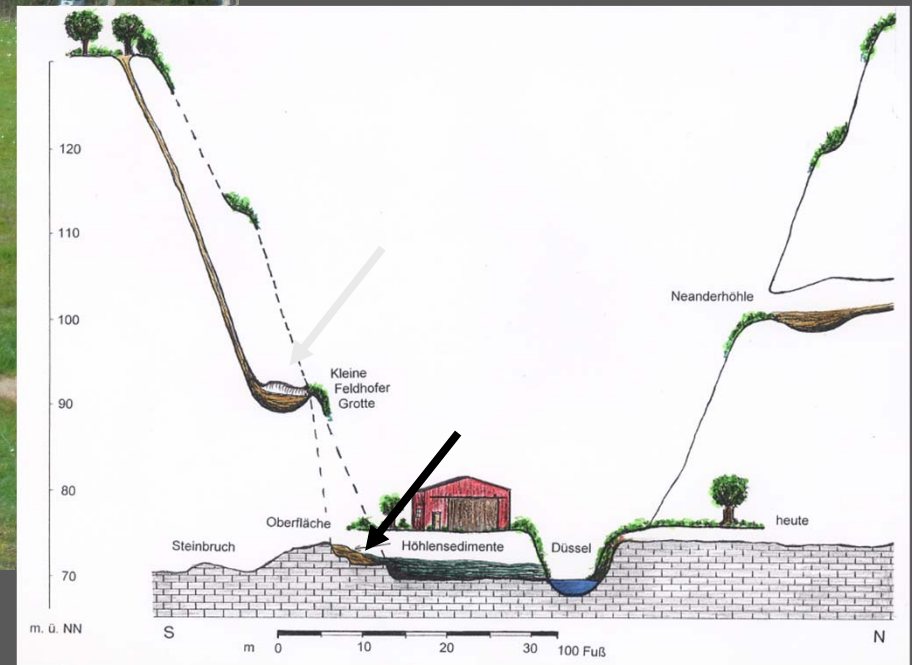
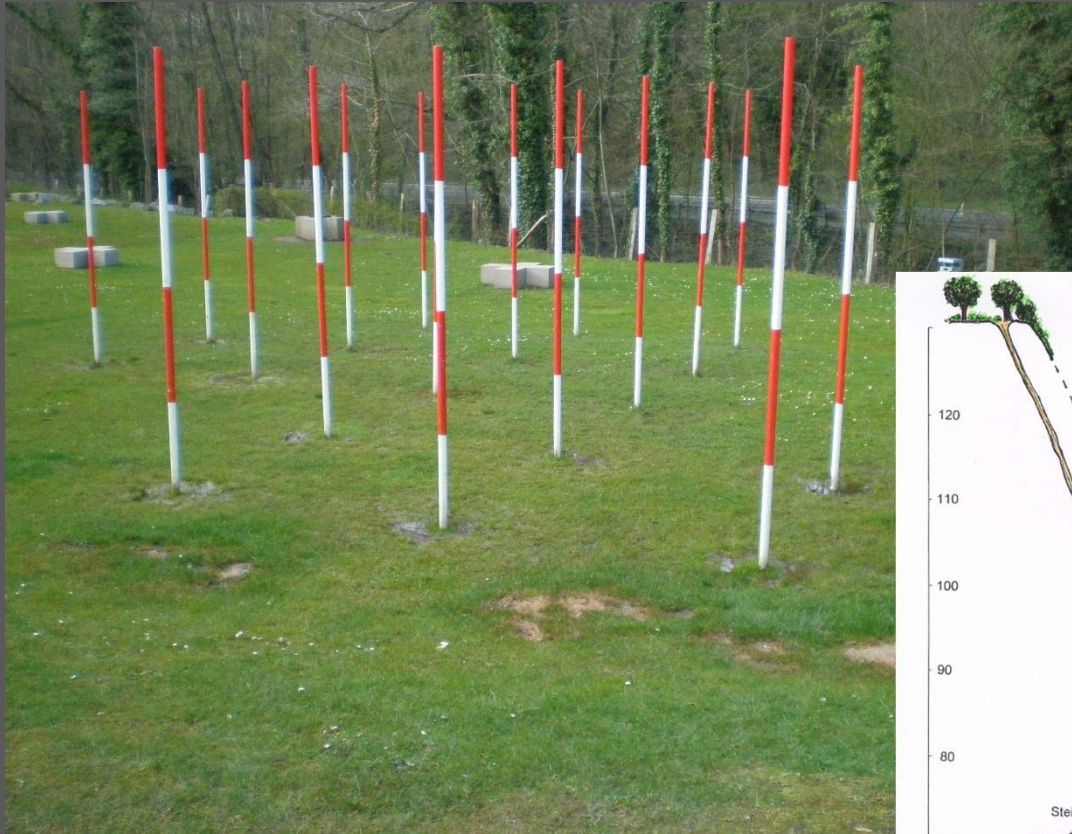
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Neandertal Man – National Museum Bonn (LVR)



# Re-discovering Neandertal Man



Type Locality „Feldhofer Grotto“ has completely disappeared



# Re-discovering Neandertal Man

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1997 & 2000: Excavation of the cave sediments re-deposited in a reversed stratigraphic sequence...

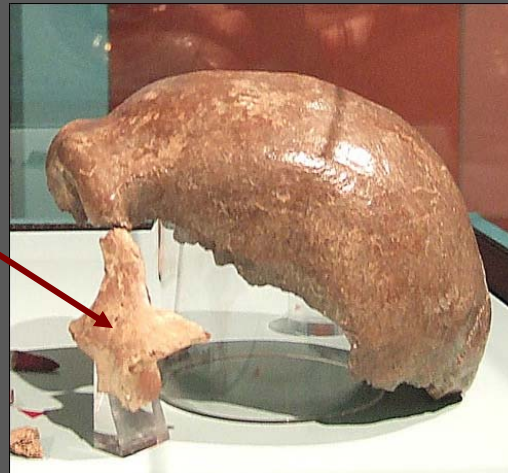
# Re-discovering Neandertal Man

70 more bones from 3 individuals found in 1997 and 2000: A woman and a child of 11-14 years joined Neandertal Man

Bone fragment found in 1997 fits to the knee joint discovered in 1856



Cheek bone found in 1997 fits to the original skull cap from 1856



The excavators:  
Jürgen Thissen & Ralf Schmitz

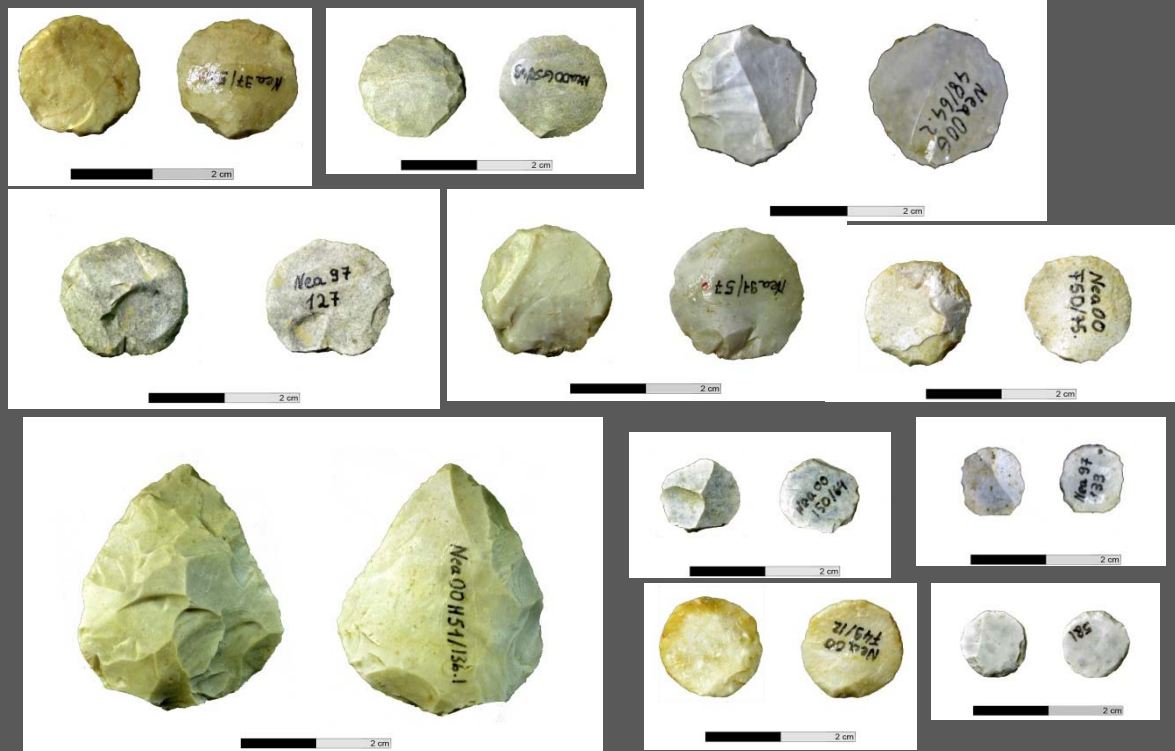




# A 'modern' lithic assemblage of Neandertal Man?



Neandertal Man at Bonn Museum



Geometric micro tools (scrapers 'Type Groszak') and projectile point from the Neandertal type locality. Sizes of the complete and thoroughly retouched thumbnail scrapers between 7-16mm! (Schmitz & Thissen 2000, Schmitz 2003, Pawlik 2011)



# A 'modern' lithic assemblage of Neandertal Man?

Lithic and microwear analysis since 2011. First results:

All analysed micro scrapers (39 out of 60) were probably used

Hafting residues and hafting polish appear on most artefacts

Precision tools for scraping and cutting activities

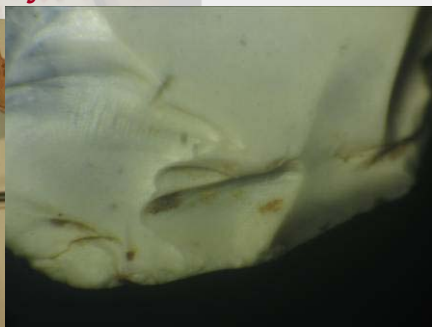
Hard and soft contact materials including grass plants.

Several artefacts with impact traces: Projectile points?

Longitudinal impact wear: laterally hafted projectile armatures?

Functional analogy to Late UPL / LSA assemblages?

Modern traits directly associated with Neandertal fossils!



# Behavioural modernity in the Middle Palaeolithic?

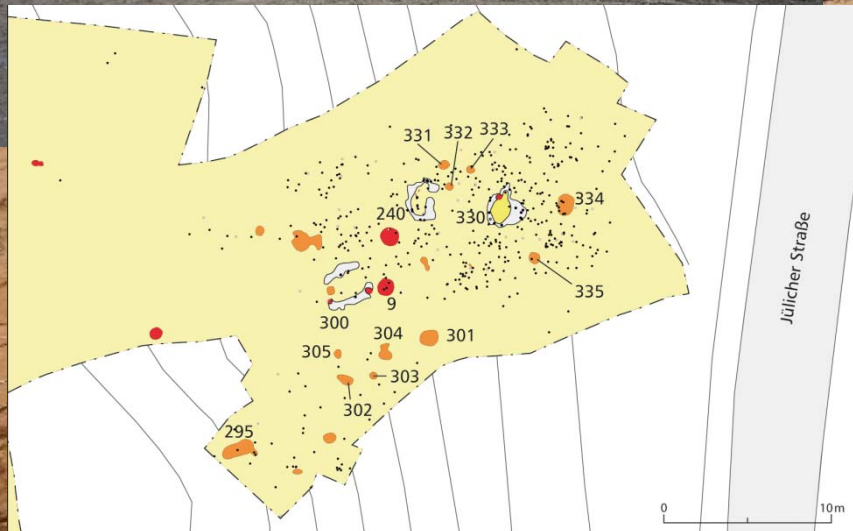
Inden-Altdorf, Lower Rhine valley, GER





# Behavioural modernity in the Middle Palaeolithic?

Inden-Altdorf, Lower Rhine valley, GER





# Behavioural modernity in the Middle Palaeolithic?

Inden-Altdorf, Lower Rhine valley, GER





# Behavioural modernity in the Middle Palaeolithic?

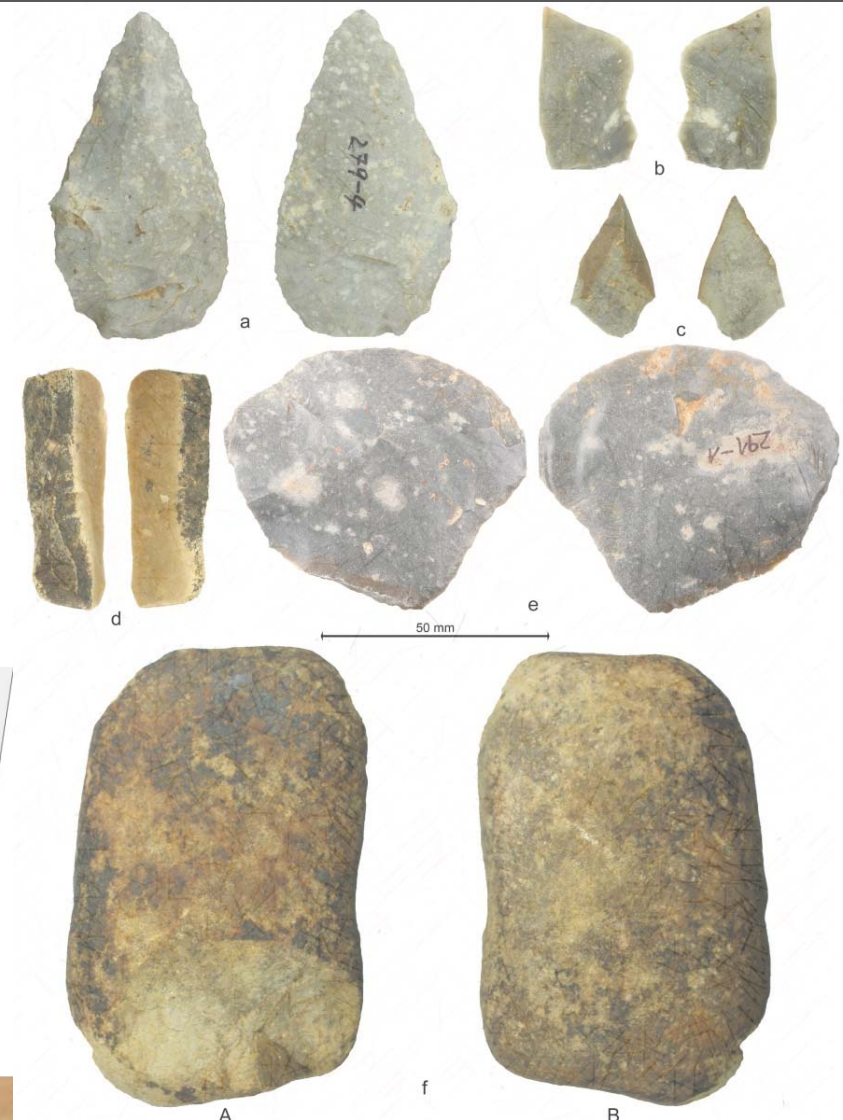
Inden-Altdorf, Lower Rhine valley, GER

Multi-level microwear analysis:

- Optical High and Low Power Analysis
- Scanning electron microscopy
- X-ray microprobes (EDX)

136 artefacts selected for analysed

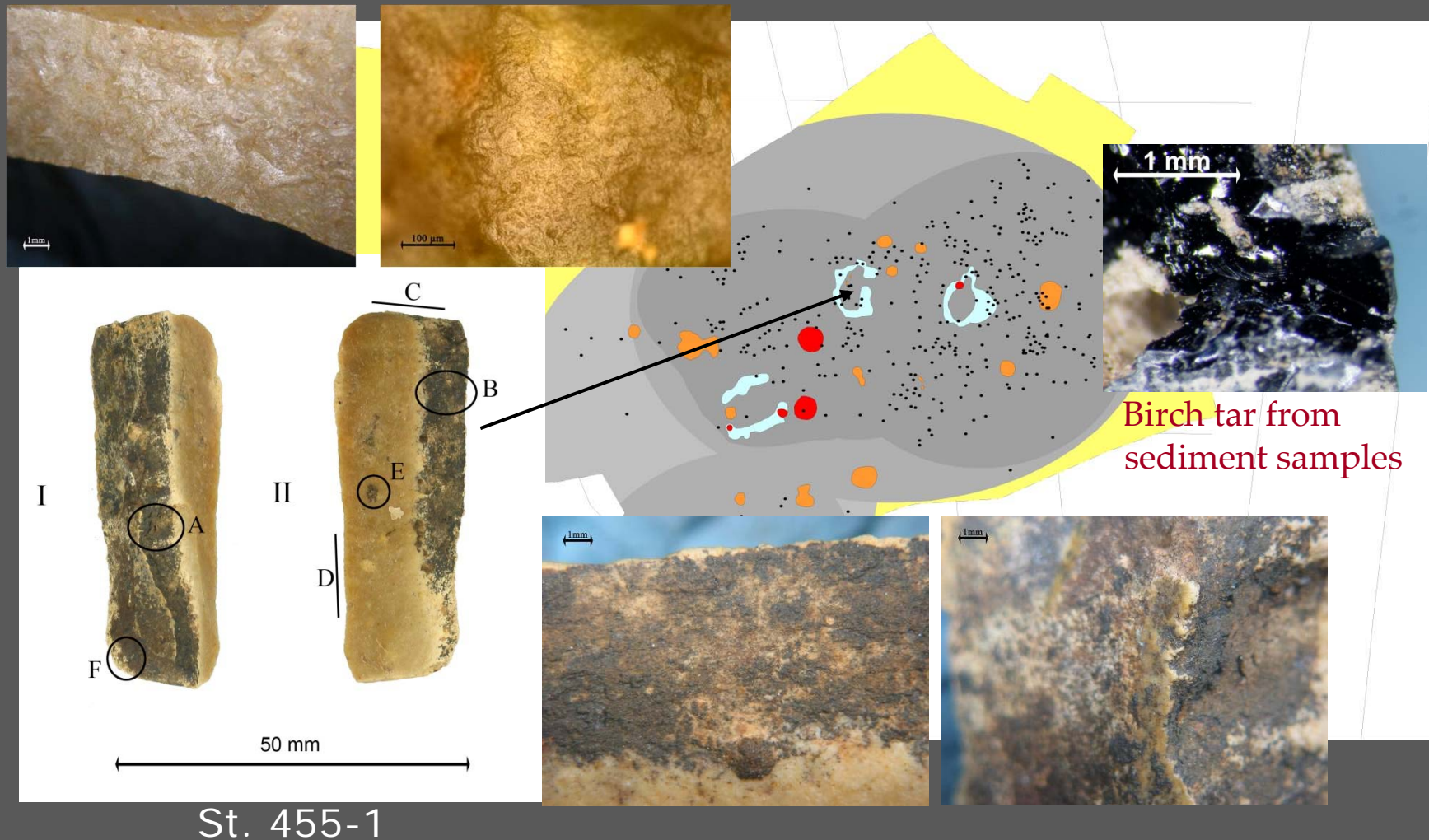
120 showed distinctive wear traces



# Inden-Altdorf: Microwear analysis

Blade used for processing of hide/leather

Laterally covered with residues of hafting adhesive: **Birch tar!**

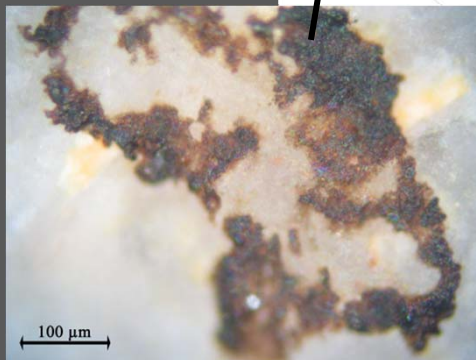
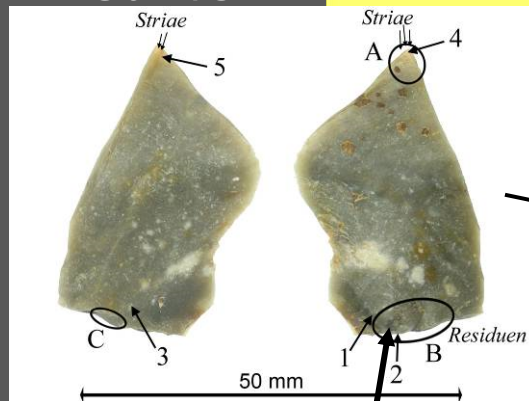




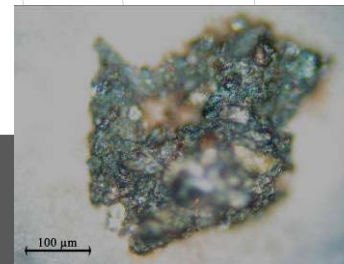
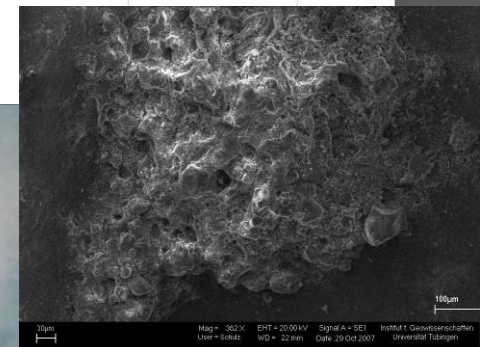
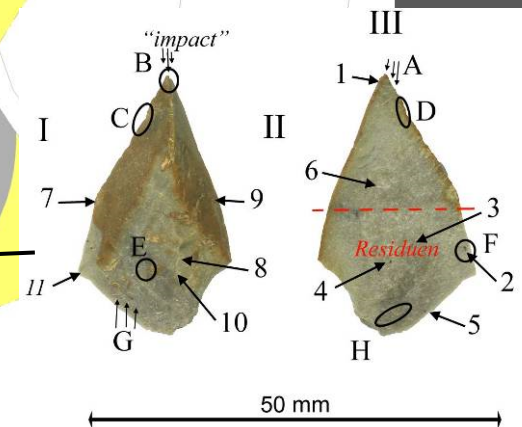
# Inden-Altdorf: Microwear analysis

Projectile points with impact scars and hafting wear/residues from 'Shelter 2'

St. 467-1

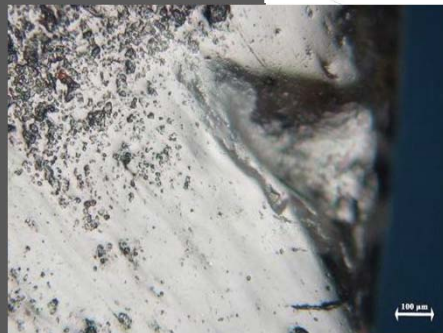


St. 470-1

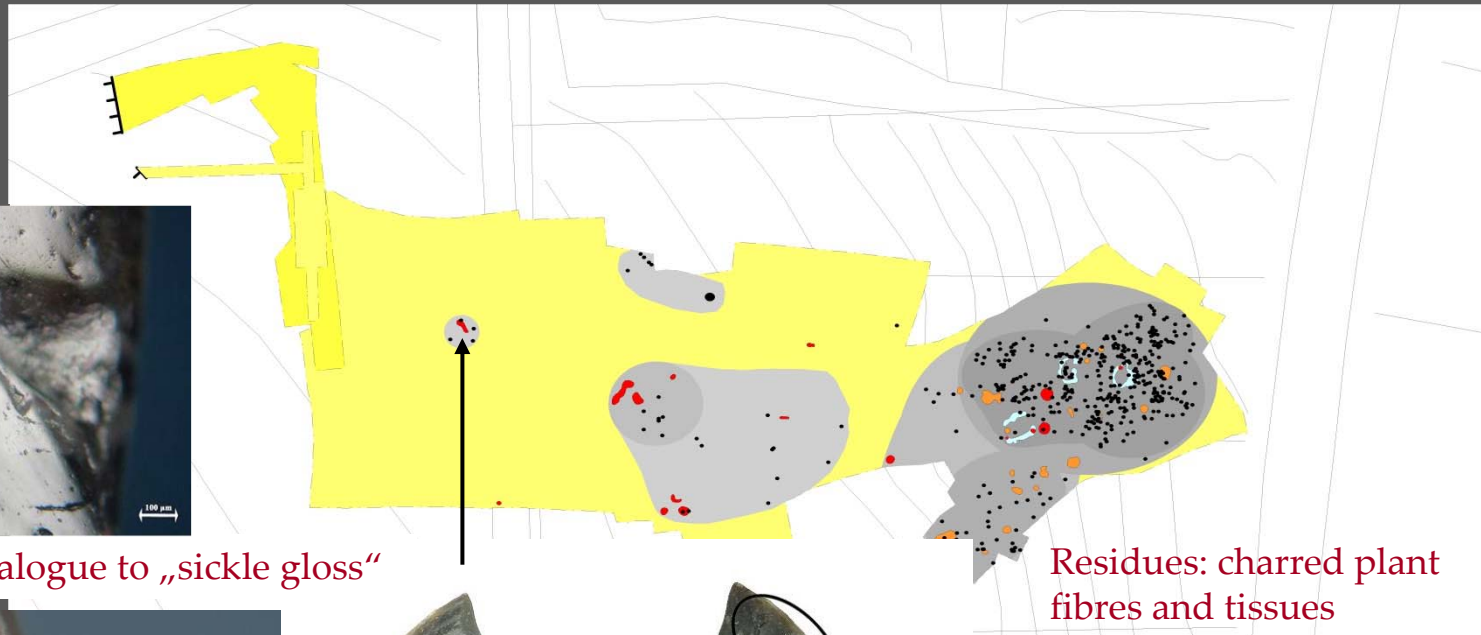


# Inden-Altdorf: Microwear analysis

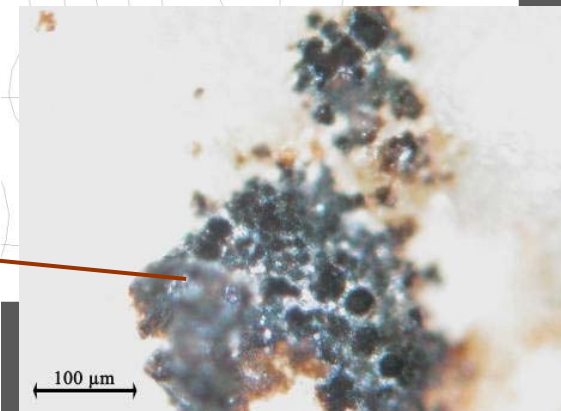
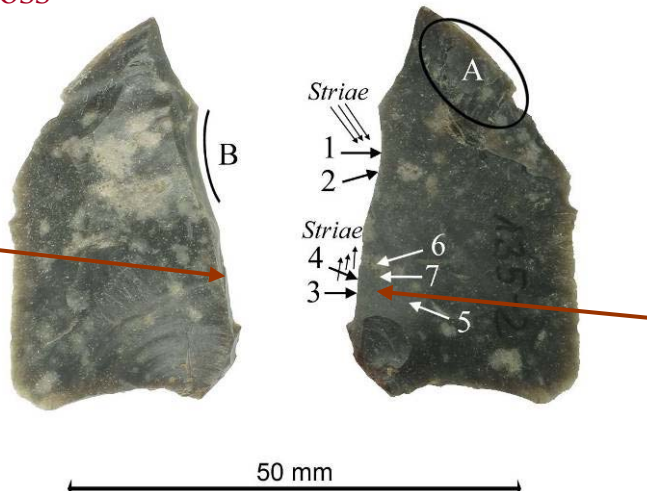
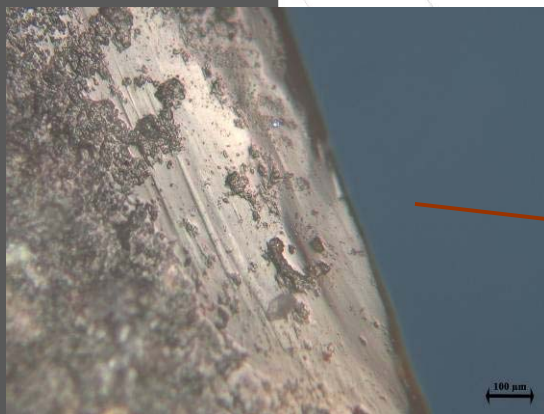
## Processing of phytolith-rich plants



Micropolish analogue to „sickle gloss“



Residues: charred plant fibres and tissues

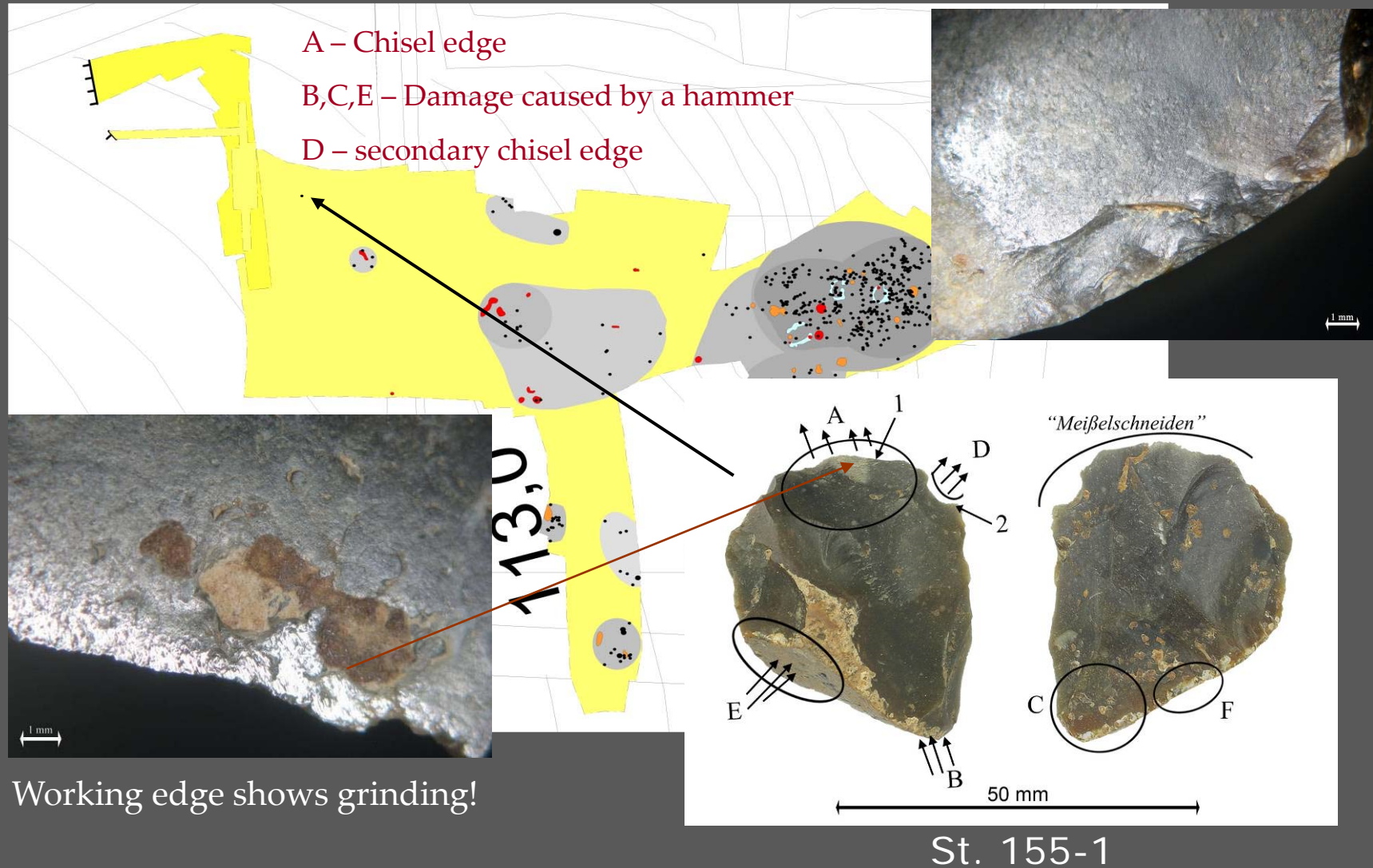


St. 135-2



# Inden-Altdorf: Microwear analysis

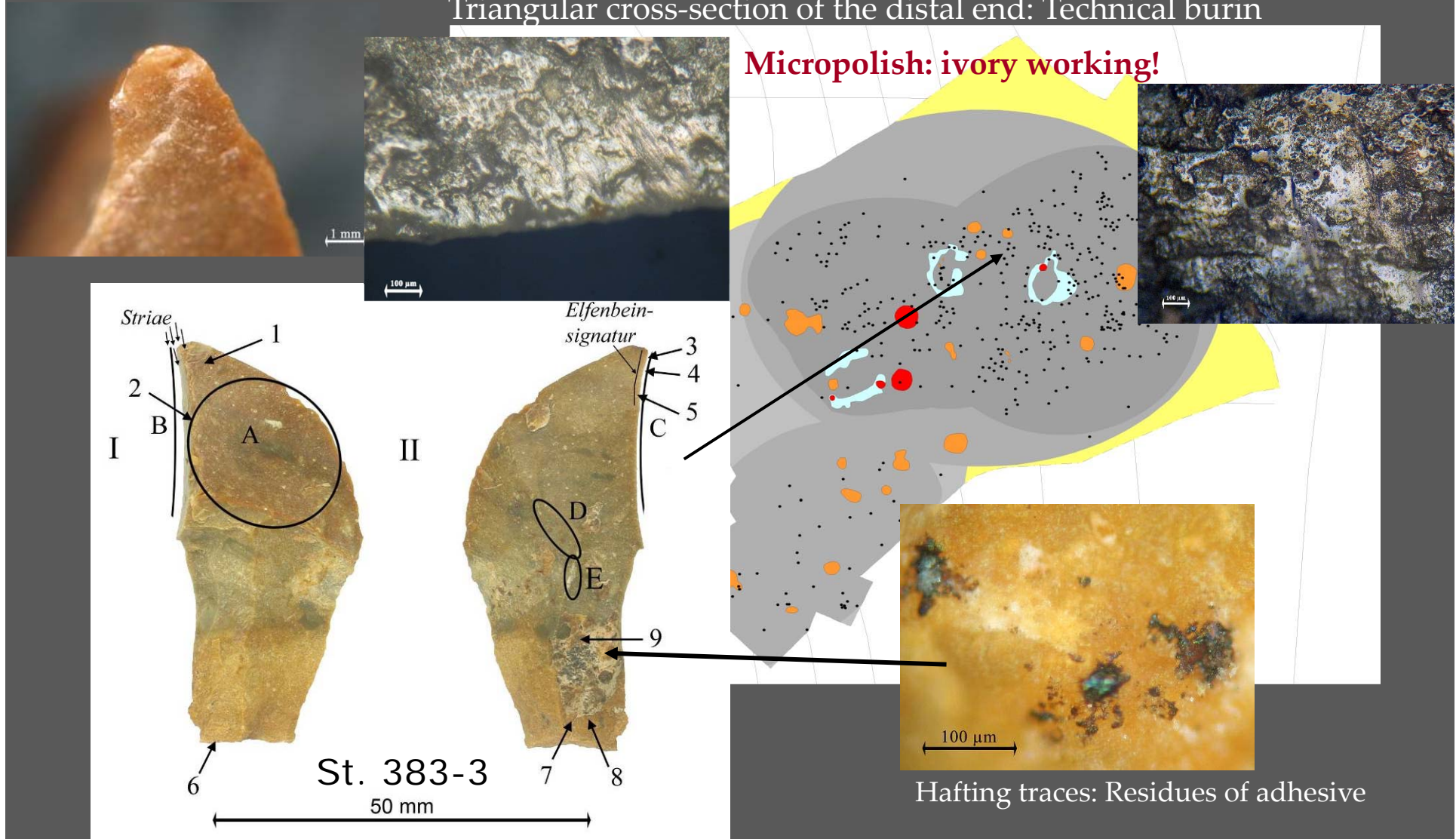
Chisel for splitting hard organic materials, e.g. bone



# Inden-Altdorf: Microwear analysis

Working of hard materials

Triangular cross-section of the distal end: Technical burin

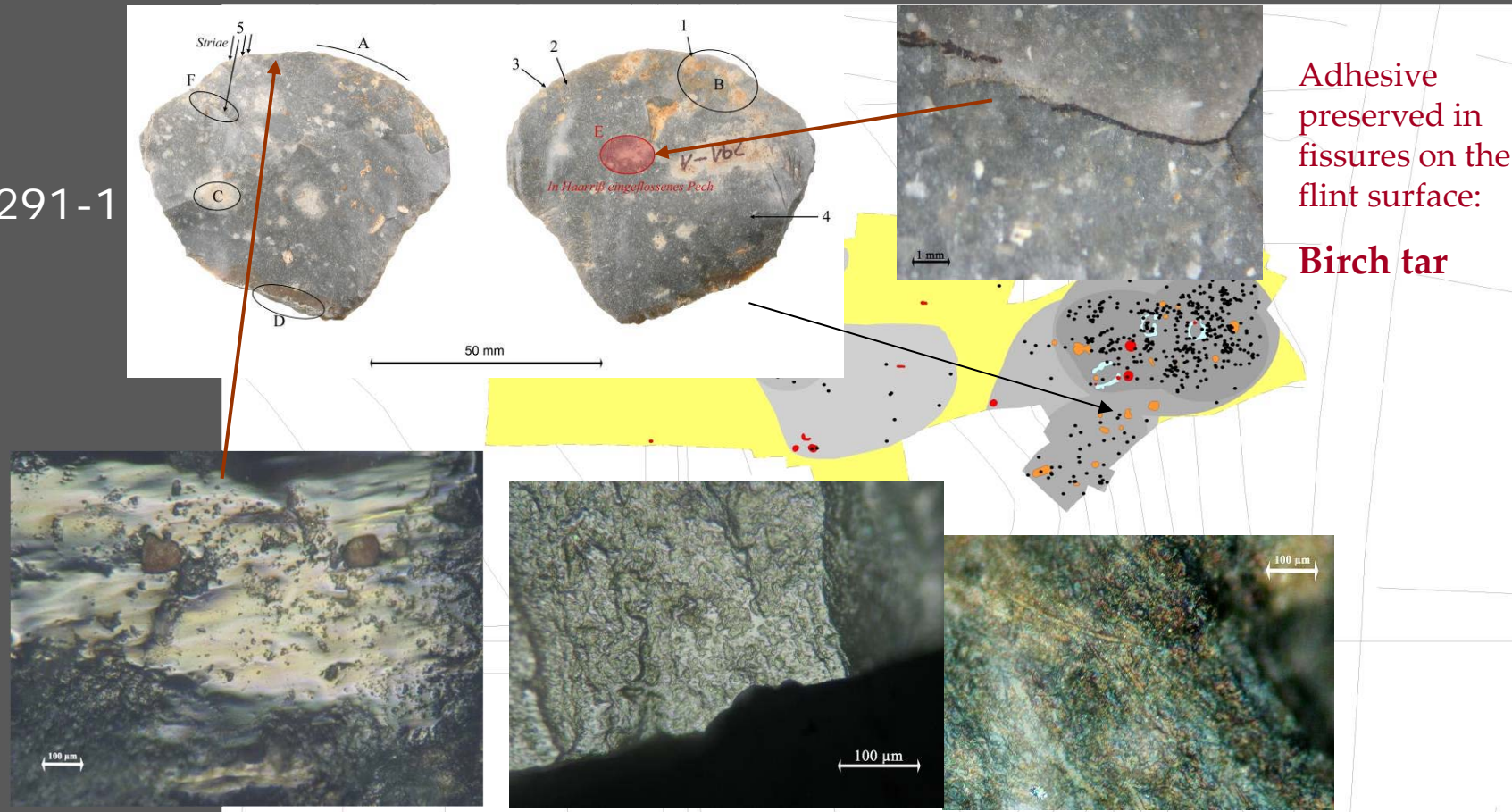




# Inden-Altdorf: Microwear analysis

Multi-functional hafted tool for plant processing: Wood and grasses

St. 291-1



„Sickle gloss”: Processing of grasses

Traces of wood working: Micropolish and fibrous residues

# Birch tar distillation and composite tool production

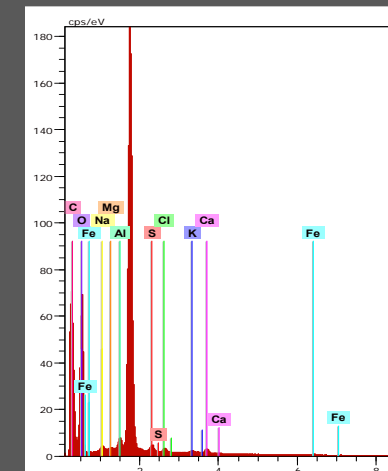
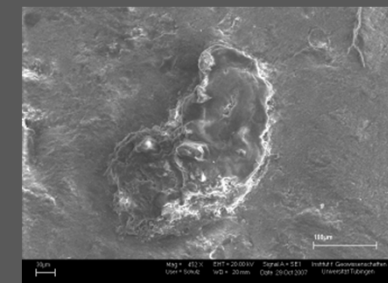
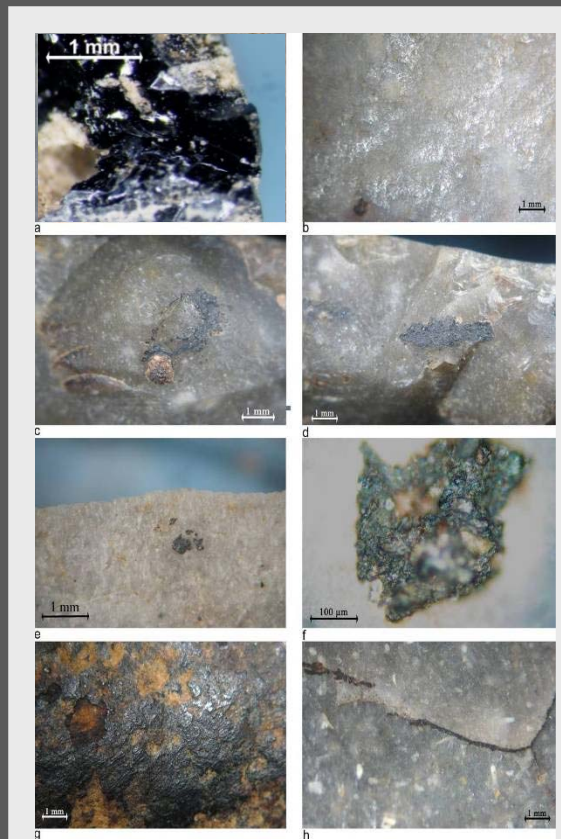
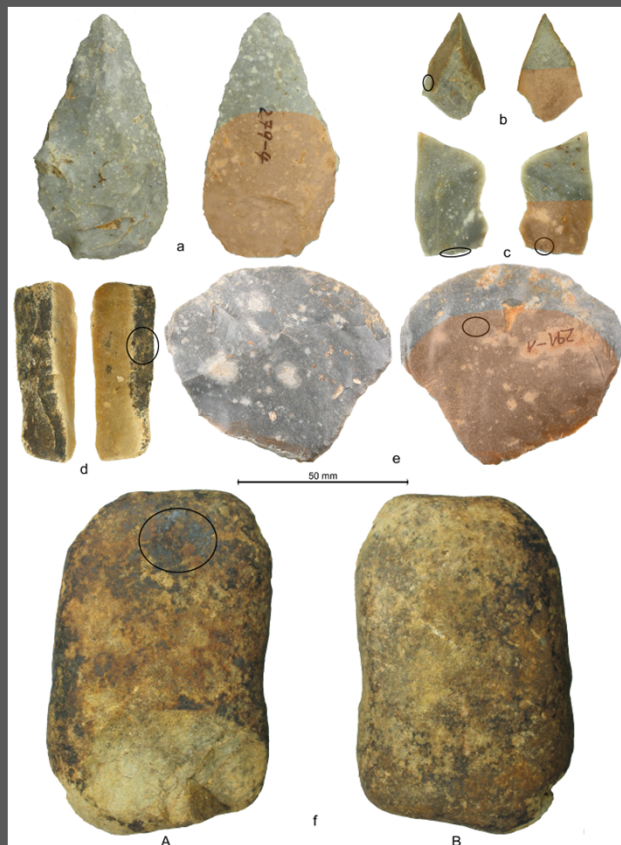
## Inden-Altdorf:

10 different activity zones

Minimum of 39 hafted implements / At least 14 tools used for hafting/retooling activities

Several flat pebbles covered with tar probably used in the manufacturing process

Evidence for frequent use of hafting technology with synthetic adhesives during OIS 5e!





# Behavioural modernity independent from species?

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**Results:** Neandertal and Altdorf possess multiple traits of diverse and complex behaviour and constructive memory and planning:

- Construction of tent-like shelters
- Geometric tool technology
- Composite tool design
- Production of adhesives
- Manufacture and use of projectile implements
- Manufacture and use of precision micro tools
- Grinding technology
- Working of ivory
- Processing of plants
- Symbolism?

All traits are items from the “*Modern Package*” list. They appear as early as 120,000 years BP and long before *Homo sapiens* arrived in Europe.

# Behavioural modernity independent from species?

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- No evidence for art, ornaments or symbols before the Neolithic in ISEA
- Few tools made of organic material, e.g. fish hooks
- Lack of core preparation, blades, formal tool types, curation
- Simple and unsophisticated tool technology; '*smash-and-grab*' (Coutts and Wesson 1983), '*expedient technology*' (Mijares 2002)
- Retouches and modifications mostly unintentional and caused by use
- Recognition of 'modern' traits is problematic!
- Age and morphology of fossil remains from sites like Tabon Cave, Callao Cave, or Niah Cave indicate anatomically modern humans at ca. 50,000 BP.  
Did they lose their 'Modern Package' along the way into the archipelago?
- Or do different rules for 'Modernity' apply for ISEA?
- How to detect modern behaviour, if ever?



## Three main questions from an Indo-Pacific perspective ...

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1. Is there pre-*sapiens* evidence from Asia for traits of modern behaviour?



E.g. pigment use at  
Hunsgi, India

E.g. shell fishing of  
*Homo erectus* in Java

## Three main questions from an Indo-Pacific perspective ...

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2. How valid is the current trait list of symptoms for detecting or refuting the existence of modern human behaviour?





## Three main questions from an Indo-Pacific perspective ...

3. Can other, more general and basic aspects of modern human behaviour be identified?

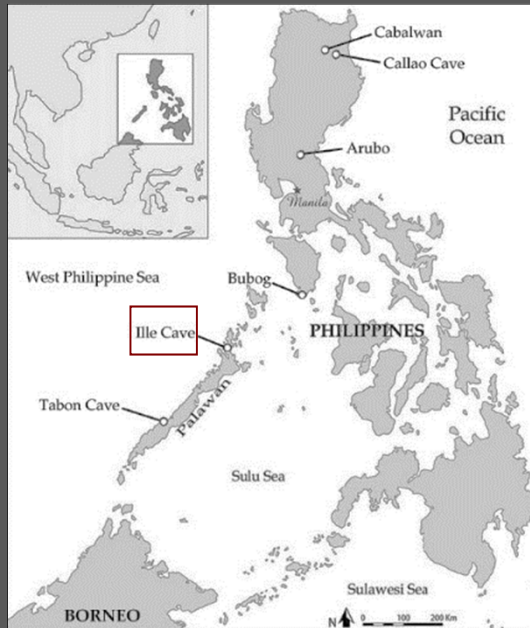


## Missing Types and the Bamboo Hypothesis?

- Lithic industries from Island Southeast Asia are generally characterised by simple production techniques and a paucity of formal stone tools.
- Therefore, some authors (Narr, Solheim, Pope, Bellwood, etc.) suggested the existence of a “lignic industries”.
- The function of most stone tools was merely to produce and maintain such specialised tools made of wood or bamboo.
- However, those “lignic industries” are hypothetical: no wooden or bamboo tool has been found in the archaeological record so far.
- Although functional analyses have shown the importance of plant working in the region during Pleistocene, finding clear evidence that bamboo tools have actually replaced lithic tool forms missing in ISEA is rather unlikely.
- Are there any other options to address the issue of the “missing types”?



# El Nido, Northern Palawan, Philippines

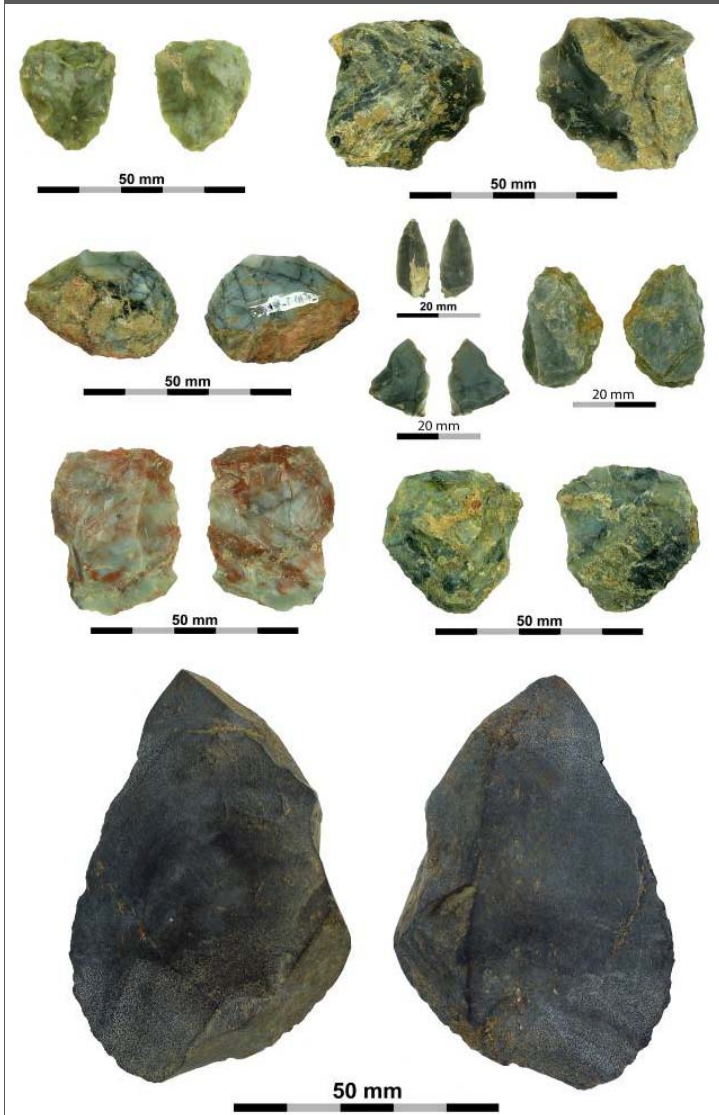


ILLE CAVE





# Ille Cave, El Nido, N-Palawan



Flaked artefacts from Terminal Pleistocene Layers of Ille Cave, c. 12-14 ky BP

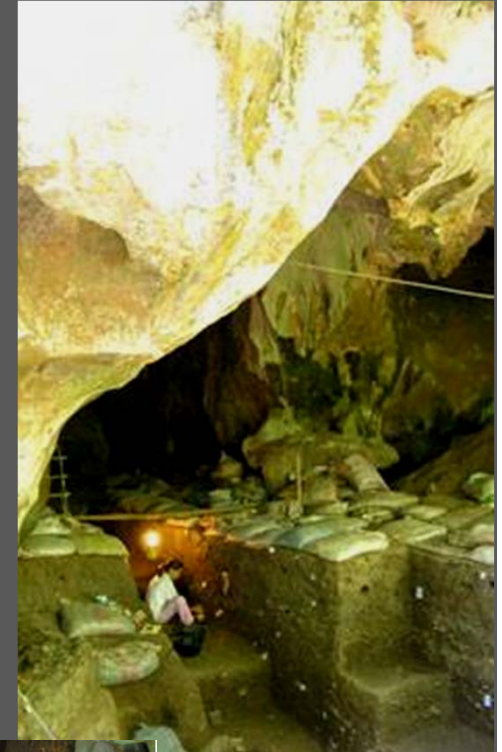
No formal tools

Typological approach not applicable

Modifications caused by use

Apparent lack of „modernity“

Consistent throughout entire Island Southeast Asia!



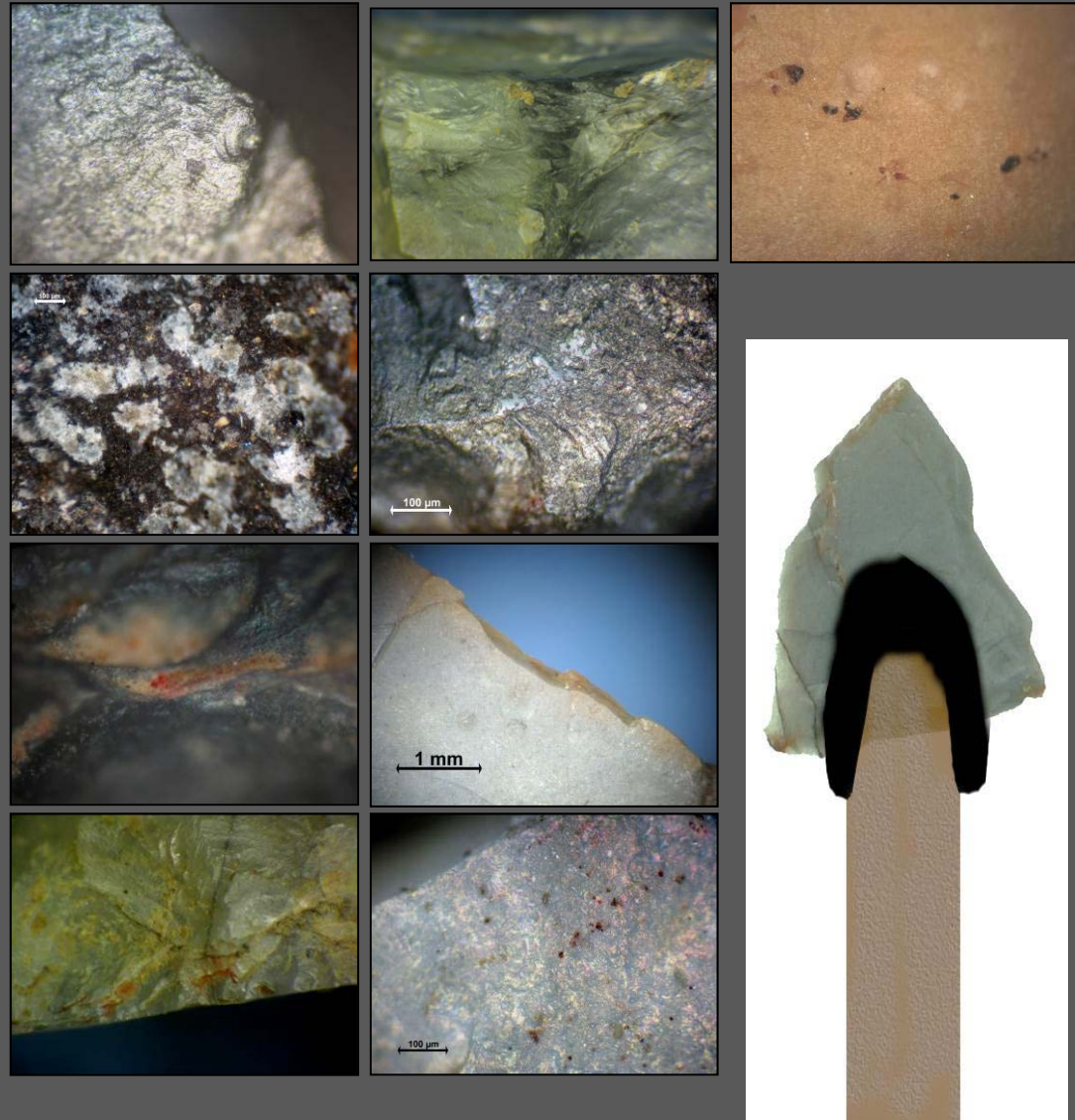
# How to detect modernity in the Archipelago?

## Possibility: **Microwear analysis**

- Determination of stone tool uses and functions
- Reconstruction of prehistoric technology and behaviour

## At Ille Cave identified:

- Wood/bamboo working
- Bone working
- Hide processing
- Shell working
- Pigment residues: Red ochre
- Signs of curation: „bright spots“
- Impact scars: Projectile points.
- Hafting traces and resin residues
- Hafted armatures, resinous adhesive and complex tool design.
- Microscopic evidence for complexity at Ille Cave during the Terminal Pleistocene!





## Perhaps the recognition of modern traits and behavioural complexity in SE-Asia requires different analytical tools?

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- Need of a more general and not geographically focused debate
- Comparison of different trait lists and their validity in other continents
- Detailed mapping of trait occurrence in short time slices
- Identification of prerequisites or special needs for different traits
- Studying the role of cultural differences / social influences on the expression of different traits of “modern behavior”

Perhaps the recognition of modern traits and behavioural complexity in SE-Asia requires different analytical tools!

Microwear analysis offers:

- Actual technical and functional characterizations of lithic artefacts

- Identification of working / hunting tools

- Identification of worked materials

- Determination of activities and site functions

- Regionally and chronologically independent

- Potential for the detection of differentiated behaviour and complex, “modern” technologies, e.g. hafting and composite tool making

**Microwear analysis can contribute to the debate on modern human behavior and cognitive advancement!**



# Not so different after all?

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