Evaluation of Cartographic Resources in Researching Landforms in High Mountains

Case study of double ridges in the Polish part of the Tatra Mountains

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Introduction

- Overview
  - Researching landforms in high mountains
    - cartography of mountain environments
    - double ridges
    - the Polish part of the Tatra Mountains: study area
  - Cartographic resources
    - topographical maps
    - thematic (gelogical and geomorphological) maps
    - aerial photography
    - non-cartographic resources
  - Evaluation and conclusions
    - methodology
    - the benchmark
    - results
    - conclusions

Researching Landforms

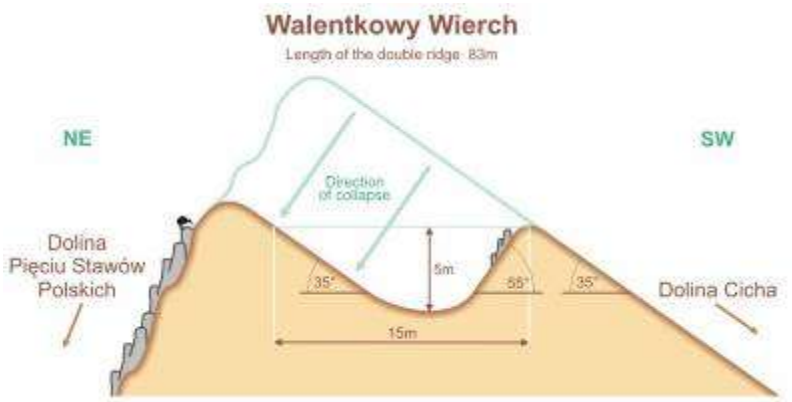
- Cartography of mountain environments
  - Representation and modelling of mountainous terrain
    - design, tools, databases and visualisations (e.g. Haeberling, 2004; Heuberger and Kriz, 2006; Hurni *et al.,* 2001; Kriz, 1999)
  - Other areas of active research
    - high mountain hazard mapping, monitoring of snow cover and glacier dynamics, cognitive aspects in mountain cartography (e.g. Kaufmann *et al.,* 2006; Kriz, 2001; Trau and Hurni, 2007; Wood *et al.,* 2005)
  - Evaluation of cartographic resources for researching landforms in high mountains
    - evaluation of DEM to represent the Hellenic Volcanic Arc (Vassilopoulou and Hurni, 2001)
      - model suitable for tectonic and geomorphological analysis
      - no examples to illustrate the performance of the model
    - updating landforms (rock and scree) representation on topographical maps (Gilgen, 2006)
      - wide range of cartographic resources used in updating process
      - no evaluation of these resources reported

Researching Landforms cont…

- Double ridges
  - Definition and terminology
    - *double ridges are relatively small longitudinal and often asymmetric depressions along mountain ridge tops* (Jaroszewski *et al.,* 1985)
    - the term *double ridge* (or *ridge top depression*) is not well recognised in English geomorphological literature despite being very fitting
      - the term is accepted among the non-English speaking scientific community
  - Characteristics
    - landform size (the Tatra Mountain example)
      - small: up to 2m deep and up to 80m long
      - medium: 2-10m deep and 80-300m long
      - large: up to 30m deep, 10-70m wide and up to 830m long
    - common landform in high mountains on all continents

Researching Landforms cont…

- Double ridges
  - Examples

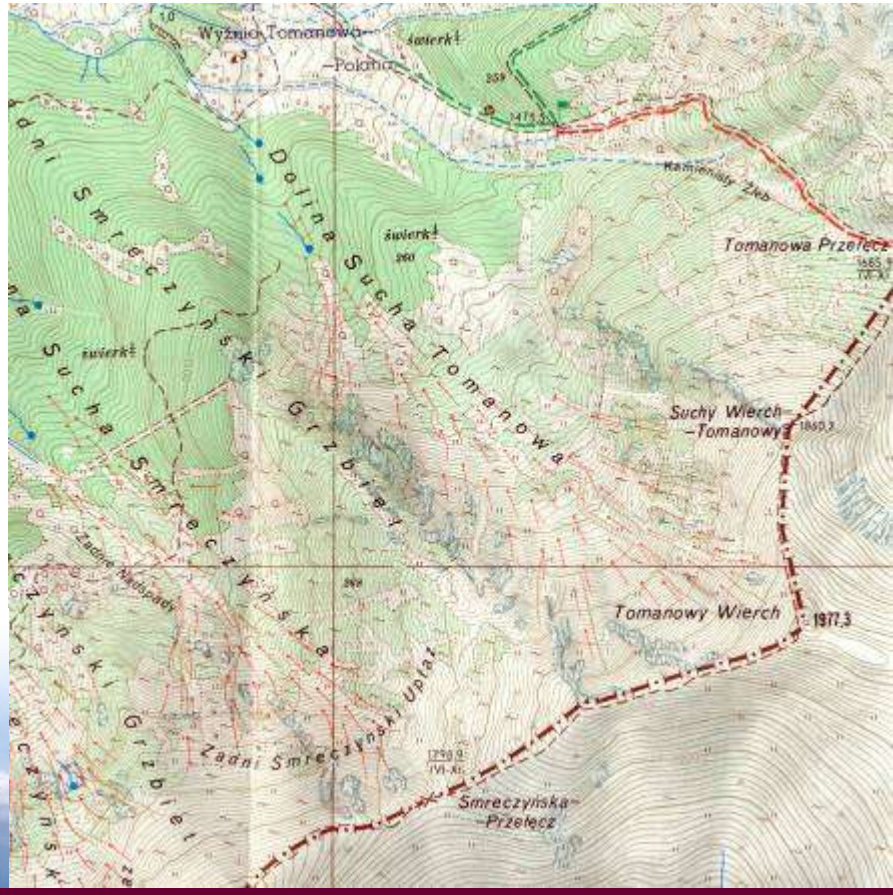


Researching Landforms cont…

- The Polish part of the Tatra Mountains
  - Study area

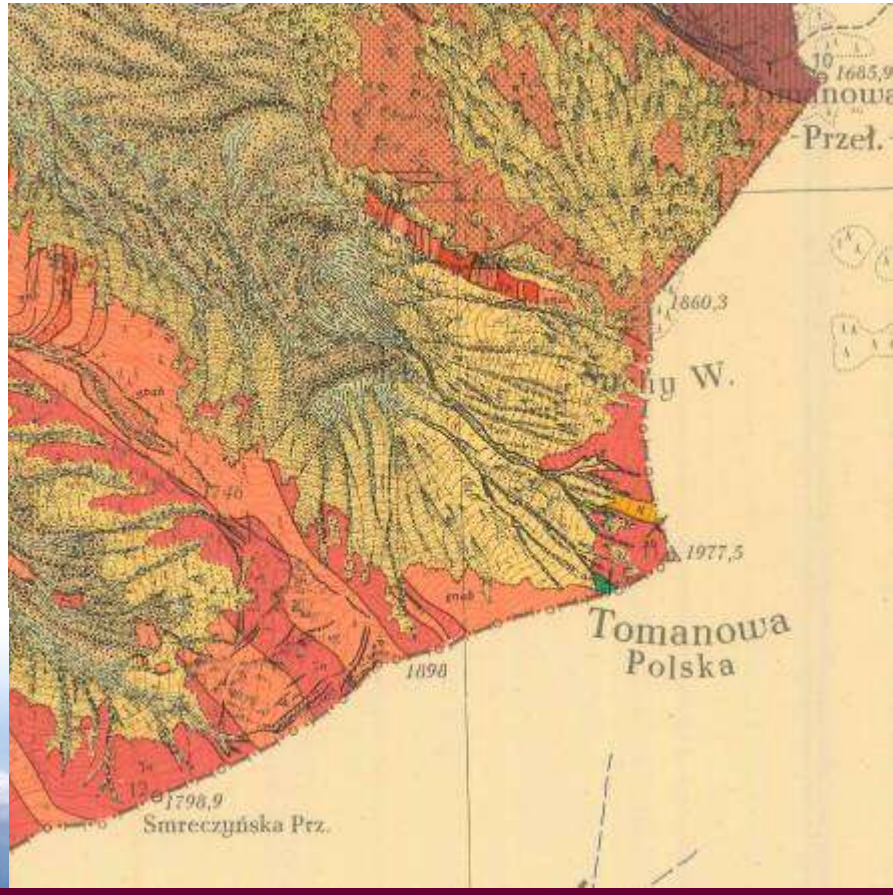
Cartographic Resources

- Topographical map (TOPO)
  - Scale 1:10 000, published in 1991 (14 sheets)
  - 5m contour interval
  - Double ridges represented by contour lines or a configuration of rock drawing symbols
  - Interpretation of landforms is sometimes difficult
    - cartographic expertise
    - geomorphological expertise
    - *a priori* knowledge



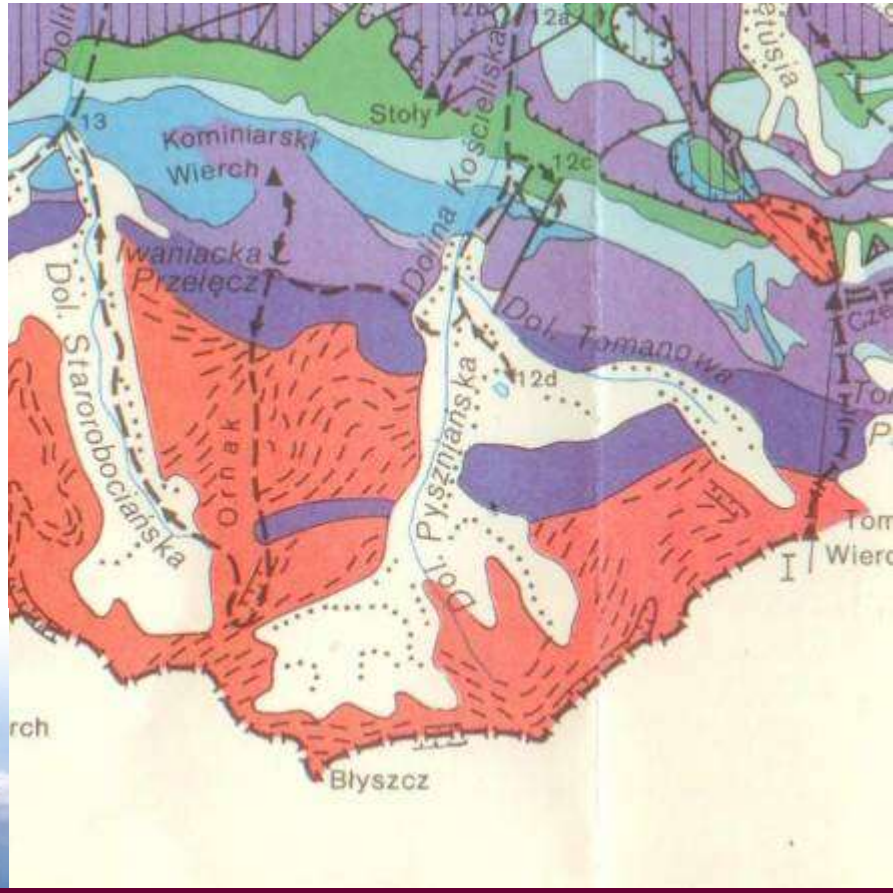
Cartographic Resources cont...

- Geological map (GEOL 1)
  - Scale 1:10 000, published in 1958 (14 sheets)
  - Detailed account of complex geology of the area
  - Double ridges represented by a series of black lines with ticks facing the inside
  - Interpretation of landforms is reasonably easy



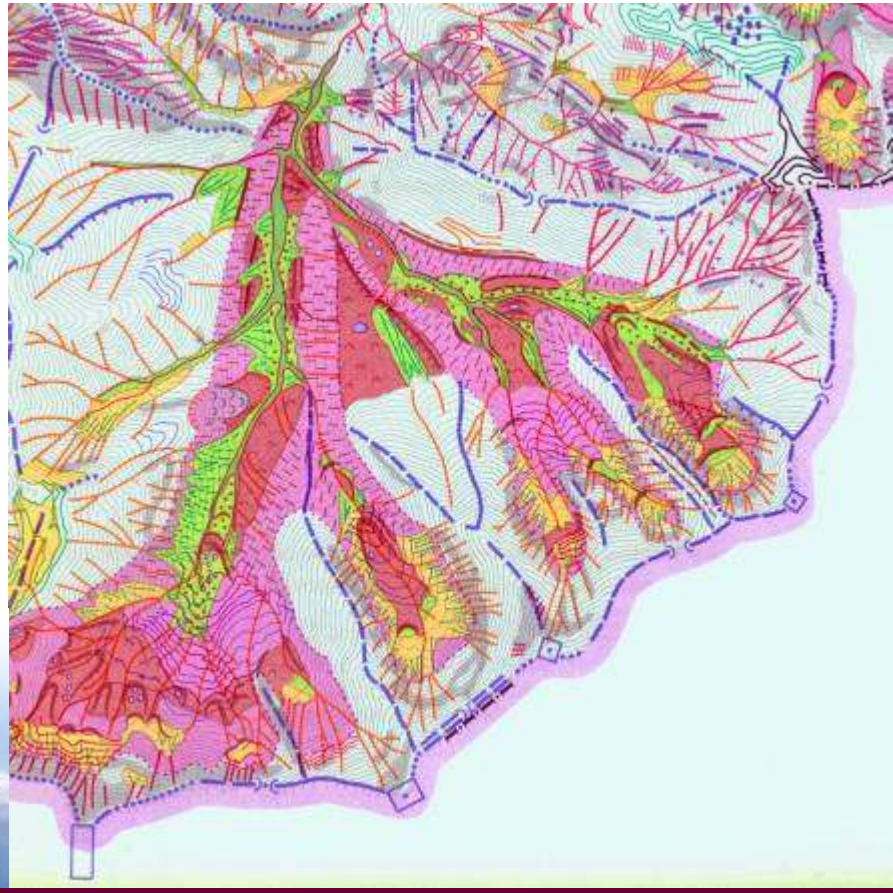
Cartographic Resources cont...

- Geological map (GEOL 2)
  - Scale 1:75 000, published in 1989
  - Generalised geology of the area
  - Double ridges represented by a dedicated black symbol
  - Interpretation of landforms is reasonably easy



Cartographic Resources cont...

- Geomorphological map (ATLS)
  - Scale 1:30 000, published in 1985
  - Detailed account of complex geomorphology of the area
  - Double ridges represented by a dedicated blue symbol
  - Interpretation of landforms is reasonably easy



Cartographic Resources cont...

- Aerial photographs (PHTO)
  - Scale 1:29 000, captured on 15 September 1999
  - Cloud-free aerial images of the area
  - Interpretation of double ridges is possible
    - good photo-interpretation skills are required in some instances
- Non-cartographic resources (KLIM)
  - Geomorphological textbook
  - List of double ridges (31)

Evaluation and Conclusions

- Methodology
  - Establishing a solid field-based benchmark
  - Evaluating cartographic resources against the benchmark using SDTS (NIST, 1991) data quality components
- The benchmark
  - A comprehensive field-based survey of double ridges
    - undertaken between 2002 and 2004
    - covering the Polish part of the Tatra Mountains
  - 39 landforms identified and described in detail

Evaluation and Conclusions cont...

- Results
  - Completeness *(extent to which information is comprehensive)*
    - number of landforms marked on cartographic resources against the benchmark (39 double ridges)
      - TOPO (51%), PHTO (28%), GEOL 2 (26%), **GEOL 1** and ATLS (20%)
  - Positional accuracy *(difference between positional observation and reality)*
    - discrepancy of double ridge locations on cartographic resource (taking into account the scale) and their *true* location
      - considering their scale, all resources displayed satisfactory positional accuracy
  - Attribute accuracy *(difference between attribute observation and reality)*
    - checking whether double ridges identified on a particular resource had their equivalent in the field
      - GEOL 2 represented two double ridge systems as one
      - KLIM listed one double ridge system as two separate ones; also KLIM listed further five landforms that were not identified against the benchmark

Evaluation and Conclusions cont...

- Results cont...
  - Logical consistency *(extent to which information components agree)*
    - checking whether representation of landforms on cartographic resources logically corresponds to their size
      - TOPO is missing two large forms, but shows several small ones
      - GEOL 2 is missing four large forms, but shows a couple of small ones
      - PHTO is the most consistent resource showing six large and 5 medium landforms
      - eight double ridges, including one large one, are not identified on any of the resources and there are further five that are listed only in KLIM (non-cartographic resource)
      - there is only one large landform that is represented on all resources
  - Other data quality components
    - lineage – only considered in the selection of the TOPO resource
    - no other components were considered

Evaluation and Conclusions cont...

- Conclusions
  - There is a number of cartographic resources that are accessible and useful in researching high mountain landforms
    - topographical, geological and geomorphological maps, and aerial photographs
  - A systematic evaluation of resources revealed their various suitability in supporting such research
    - topographical maps and aerial photographs performed best in identifying and locating double ridges in the Tatra Mountains
    - the evaluation process was limited due to the lack of appropriate metadata

Evaluation and Conclusions cont...

- Conclusions cont…
  - Many current cartographic resources are not yet sufficient for comprehensive studies of relatively small landforms
    - more detailed resources are required
    - a systematic evaluation is critical in assessing their suitability in researching double ridges or similar landforms in high mountains

Even high quality resources and rigid evaluation procedures would not completely remove a need for comprehensive field surveys

  - The adopted approach for studying double ridges was satisfactory in detecting large and medium size depressions