

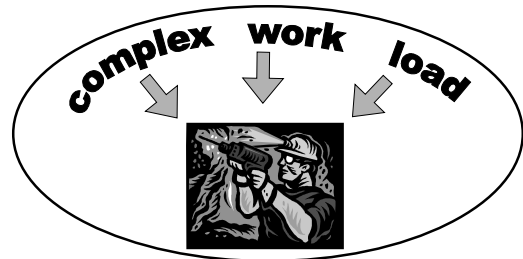
# Physiological Measurements of Complex Stress and Strain in Humans

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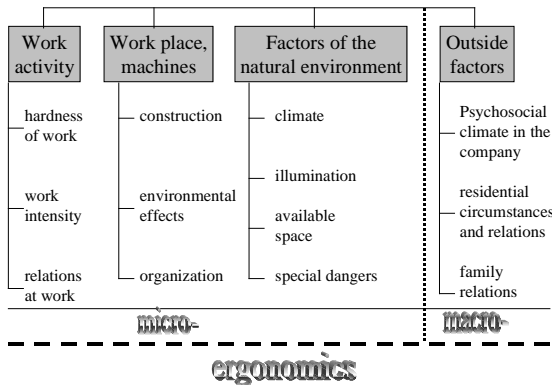
## Model of the complex load

Micro ergonomics ↔ Macro ergonomics

Optimal utilization of human power during the labor career



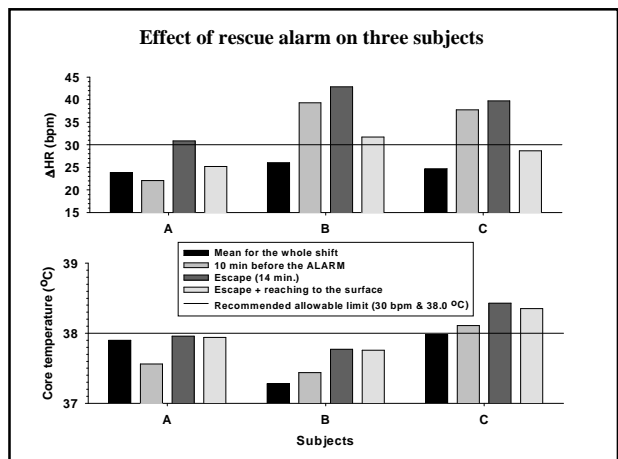
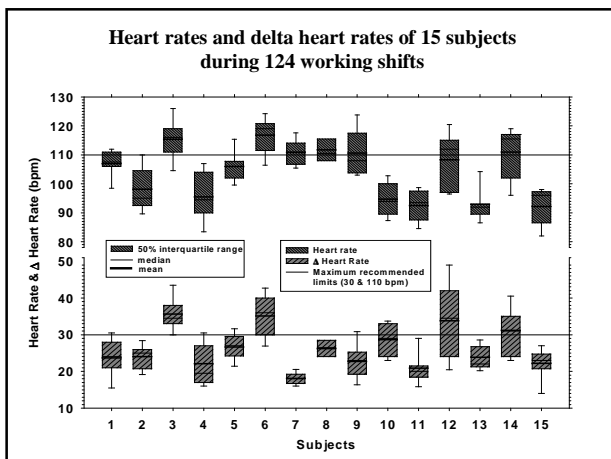
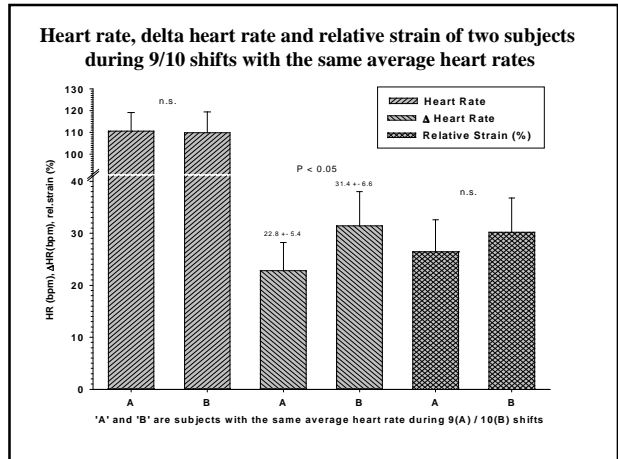
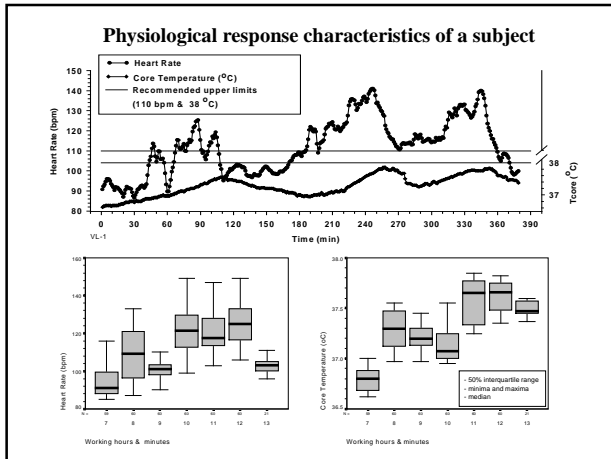
## The components of complex work load



## Characteristics of the studied workplaces

Workplace characteristics	Halimba bauxit mine (1987-1988)	Ajka coal mine (1988-1989)	Nyirad bauxit mine (1989)	Csabpuszta bauxit mine (1990)	Halimba bauxit mine (1991-1992)
Temperature (°C)	16-18	15-17	13-14	17	15-16
Humidity (%)	94-95	82-84	95-96	88	93
Noise level (dB)	70-110	65-85	80-98	93-98	88-109
Illumination (Lux)	8-15	10-14	14-20	15-22	10-15
# of shifts	201	238	110	123	122
# of miners involved	12	18	12	16	14
Age (yrs)	39 ± 9.3	33.3 ± 7.7	39.1 ± 7.8	36.2 ± 8.6	37.5 ± 9.7
Weight (kg)	76.7 ± 9.9	74.7 ± 10.1	81.6 ± 11.5	81.1 ± 11.0	84.3 ± 16.9
Height (cm)	171.3 ± 4.9	171.8 ± 8.1	171.2 ± 4.8	174.4 ± 7.0	174.5 ± 7.1
Years in mine	16.4 ± 4.6	11.3 ± 9.3	18.4 ± 8.1	10.6 ± 8.8	16.0 ± 10.5

Main characteristics of the workplaces were:  
cool, wet, noisy and poorly illuminated



**Psychological effects**  
 Effect of observation (instrument strain)  
 Presence of managers (morning shift)

**Mental effects**  
 degree of illumination  
 occurrence of accidents

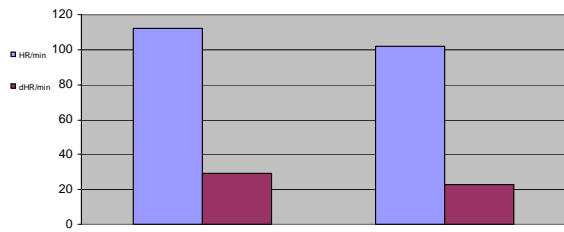
**Observation induced stress**

First measurement			Mean of 2 <sup>nd</sup> -10 <sup>th</sup> measurements		
n	HR/min	dHR/min	n	HR/min	dHR/min
15	110 ± 12	30 ± 11	110	104 ± 11	26 ± 9

**Presence of managers (day shift)**

Day shift			Afternoon and night shifts		
n	HR/min	dHR/min	n	HR/min	dHR/min
70	112 ± 12	29 ± 10	55	102 ± 10	23 ± 8

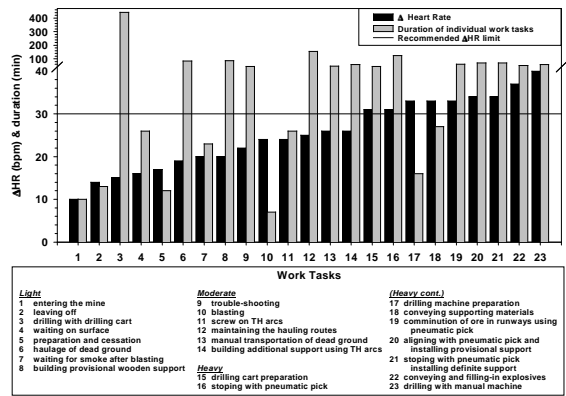
**Effect of illumination**



**Accidenting vs. non-accidenting workers**

accidenting			non-accidenting		
n	HR/min	dHR/min	n	HR/min	dHR/min
33	111 ± 13	34 ± 10	13	101 ± 9	29 ± 5

**Strain and duration of work tasks based on 124 shifts of 15 subjects**



### Comparison of different mining technologies

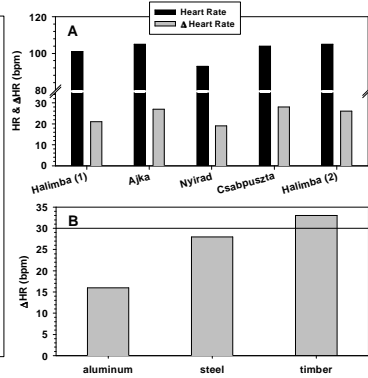
**Halimba (bauxite), 1987-1988**  
 bauxite stoping  
 light metal support  
 pneumatic LHD

**Ajka (coal), 1988**  
 drift driving  
 steel support  
 electric roadheader

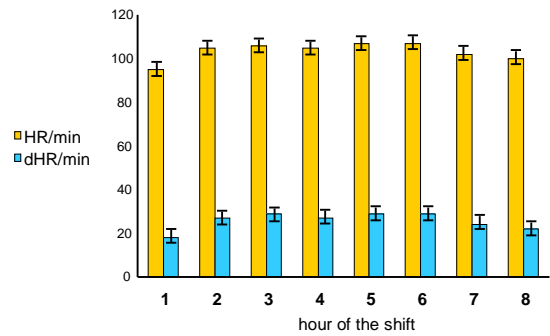
**Nyirad (bauxite), 1989**  
 bauxite stoping  
 timber support  
 diesel LHD

**Csabpuszta (bauxite), 1990**  
 drift driving in dead ground  
 varying support material  
 hand- and mechanized drilling  
 diesel LHD

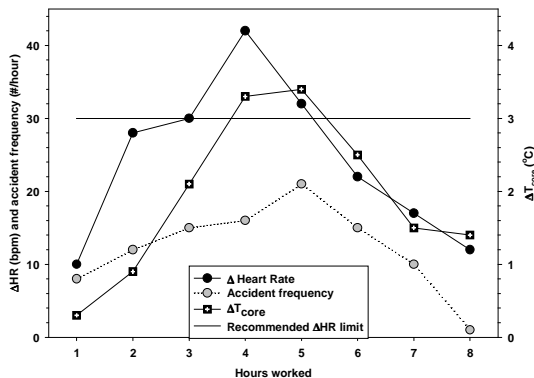
**Halimba (bauxite), 1991-1992**  
 bauxite stoping  
 steel supporting material  
 diesel LHD



### Development of strain during work



### Association of physiological strain with accidents



### Summary and conclusions

Work strain is complex.  
 Formerly investigation focused solely on the effects of physical load.  
 Complex strain is measurable and can be analysed.  
 The methodology can be utilised in optimising workstrain and by qualification of workability.  
 We continued the investigation by using HRV analysis (~900 workers, ~4000 shifts).  
 Publications of the results are coming soon.

