RWTH AACHEN UNIVERSITY

Variant selection during twinning

Sijia Mu, John J. Jonas, Günter Gottstein

Institute of Physical Metallurgy and Metal Physics

Texture and anisotropy, University Caen, 31 May, 2012

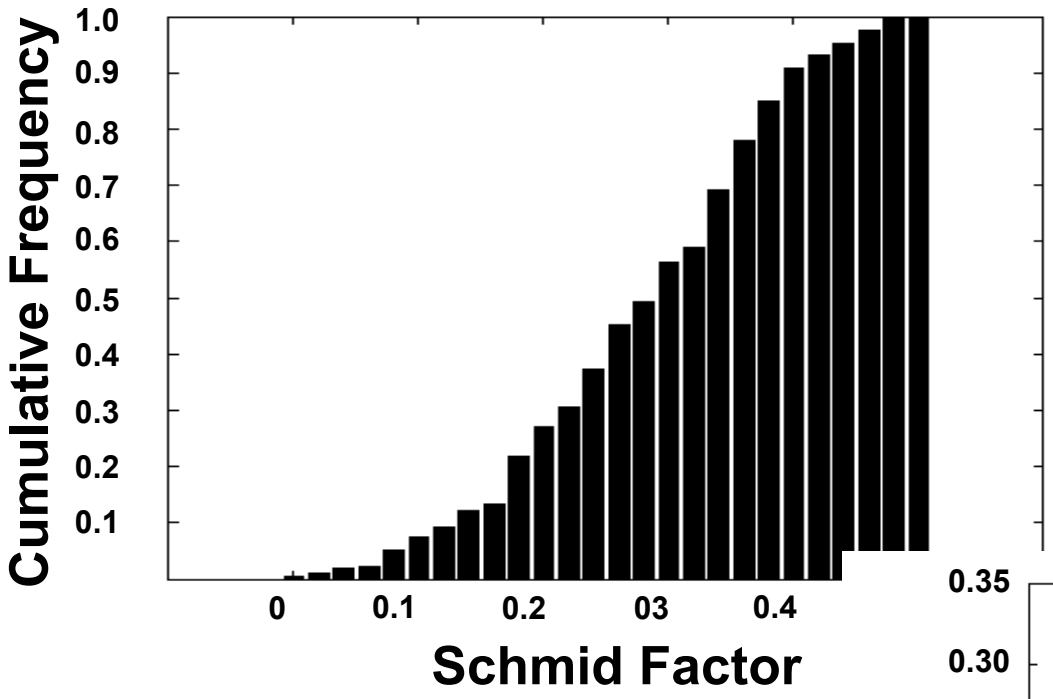
Variant Selection During Twinning

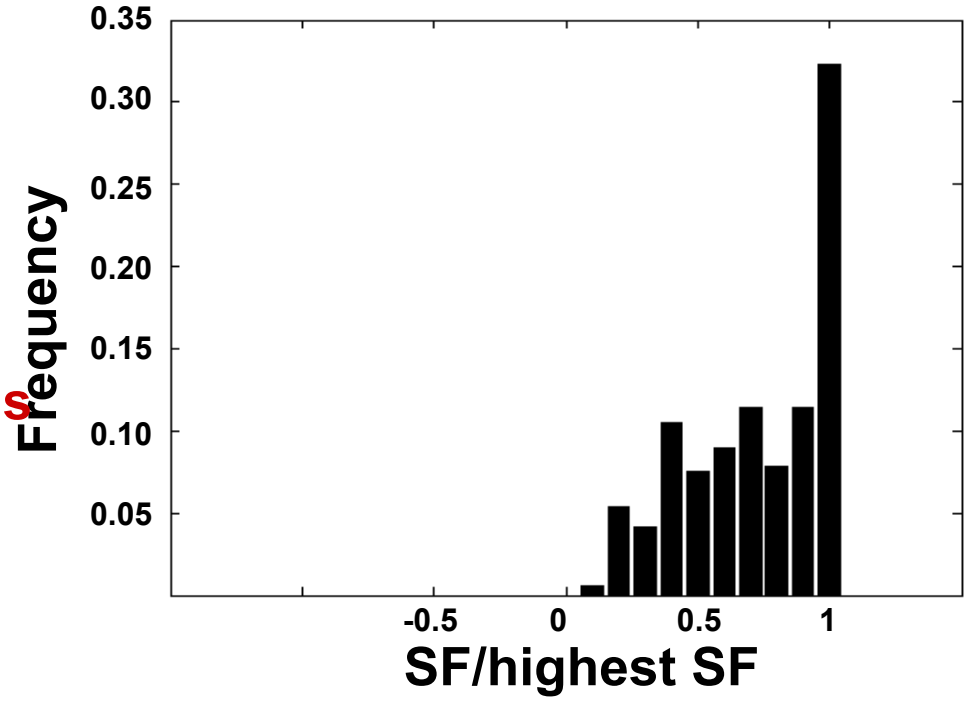
- **Introduction and motivation**
- **Schmid factor vs internal stress**
- **Taylor modelling**

Institut für Metallkunde & Metallphysik
RWTH Aachen, Germany

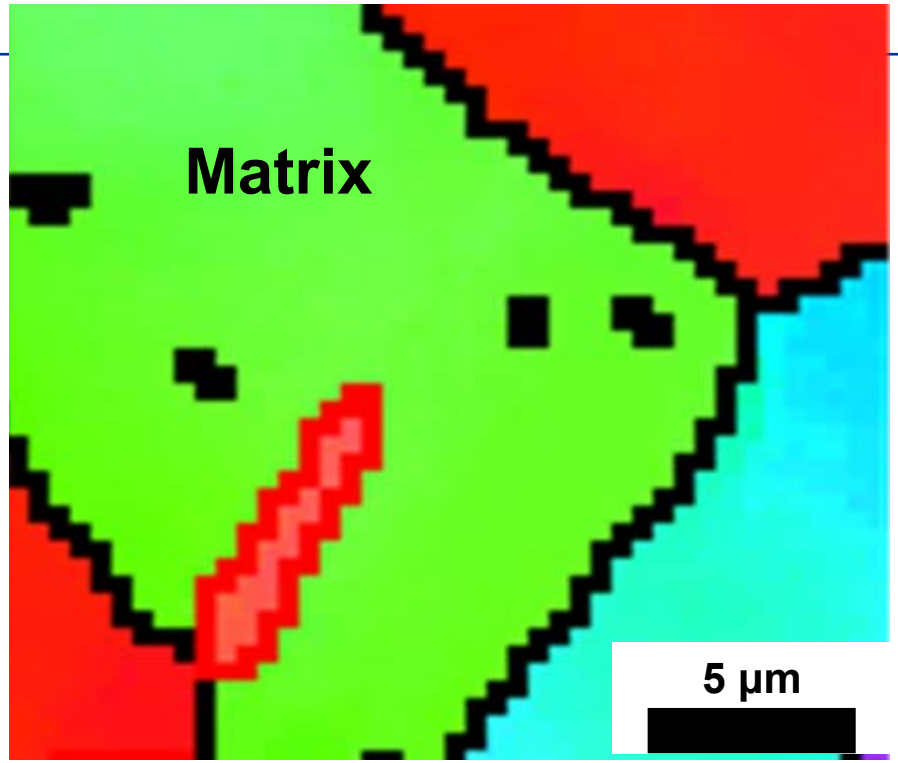
Materials Engineering, McGill University
Montreal, Canada

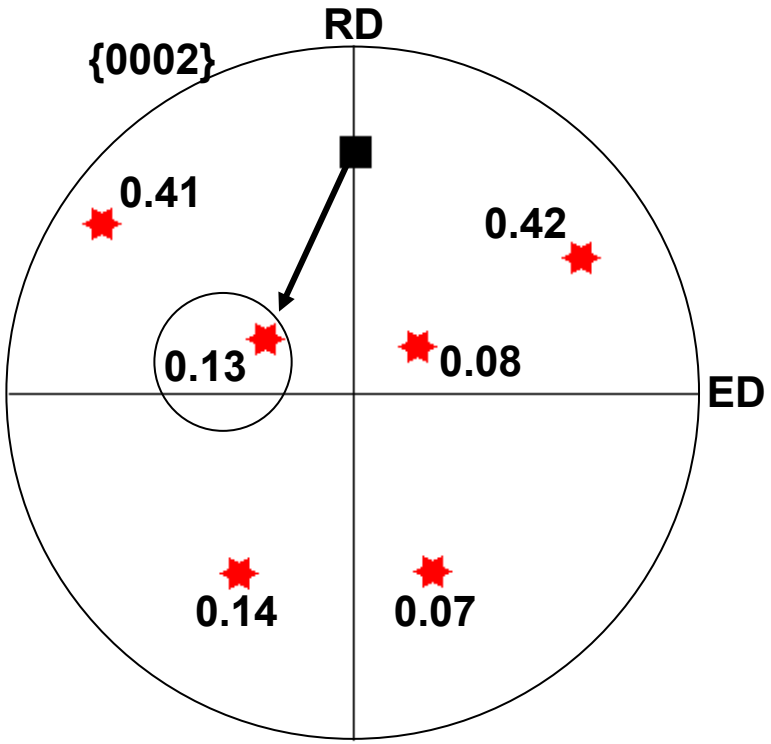
SF Distribution in AM30 (530 Primary CTW)





10 – 20% Low Schmid Factor Twins





Questions

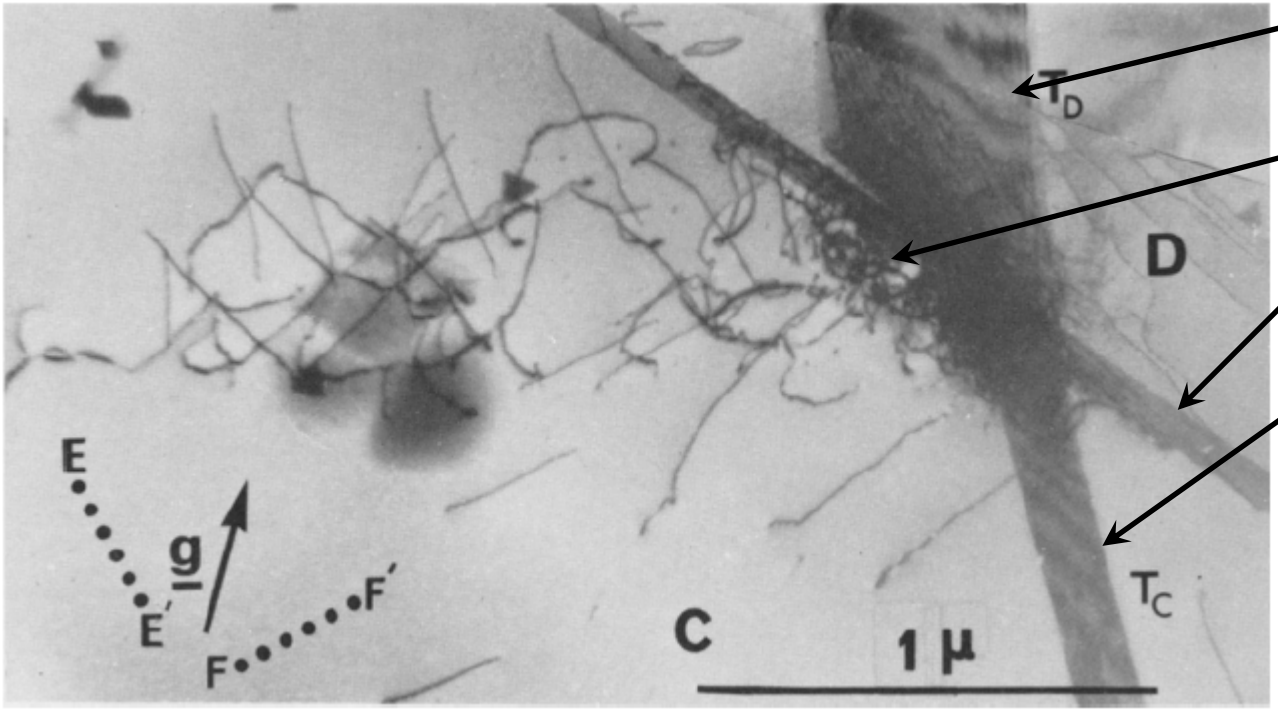
How to explain the presence of low Schmid factor twins?

How to account for the absence of potential high Schmid factor twins?

Subtitle: The Schmid factor vs. the internal stress

Accommodation Strains associated With Primary Twins

Interaction of a Twin with a Grain boundary in a Deformed Mo Alloy



S. Mahajan, Metallurgical Transactions A, 12A (1981)

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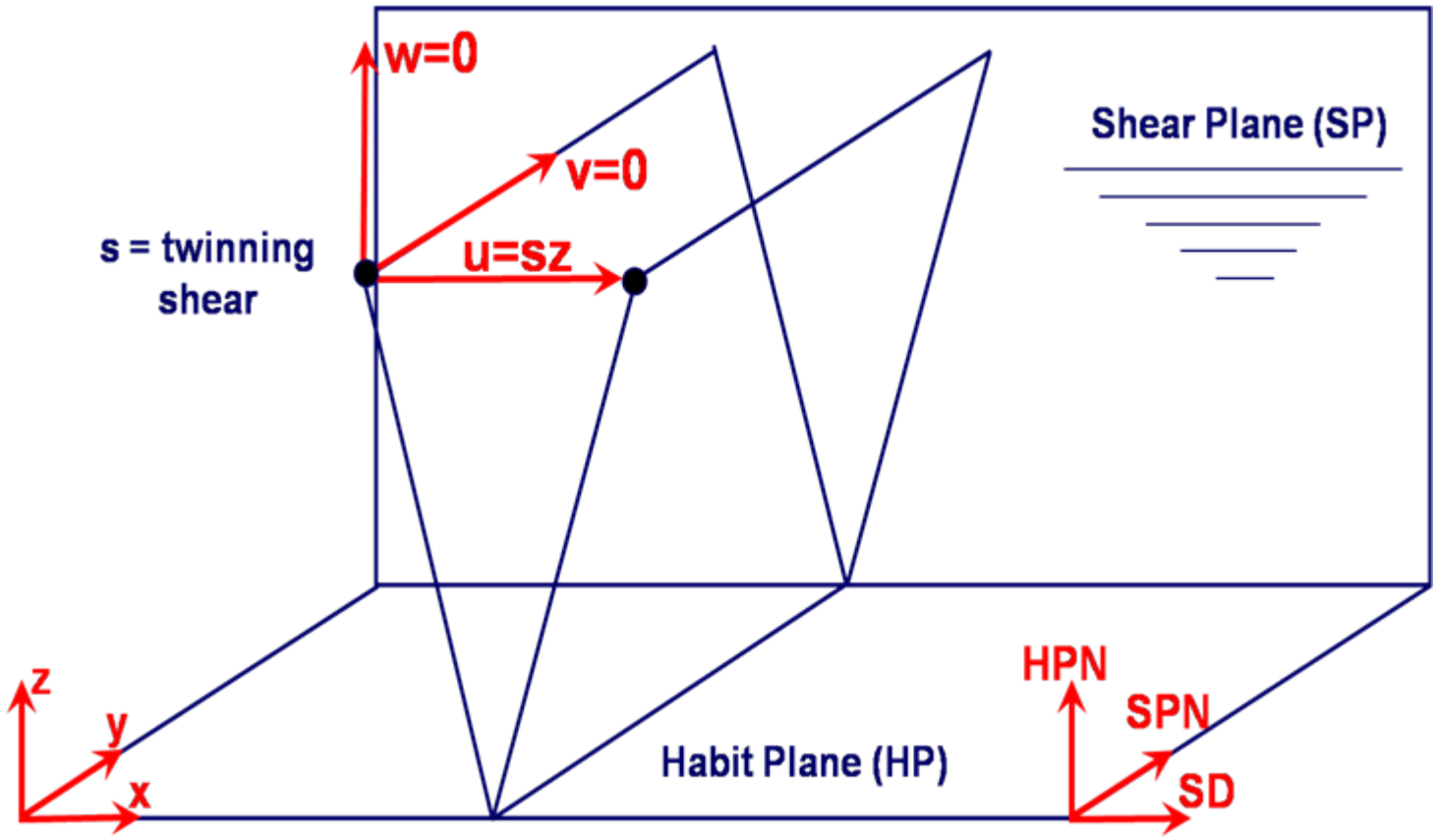
Reference Frame and Displacement Gradient Tensor of the Twinning Shear

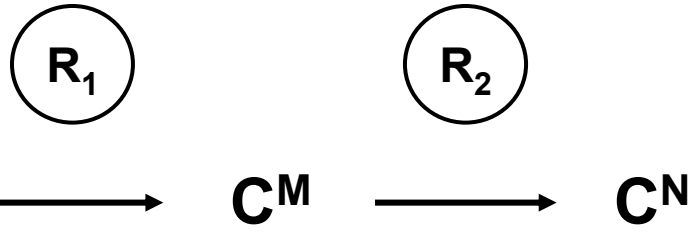


$$\begin{pmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{pmatrix}$$

Accommodation strain

Reference Frame Rotations

Primary Twinning

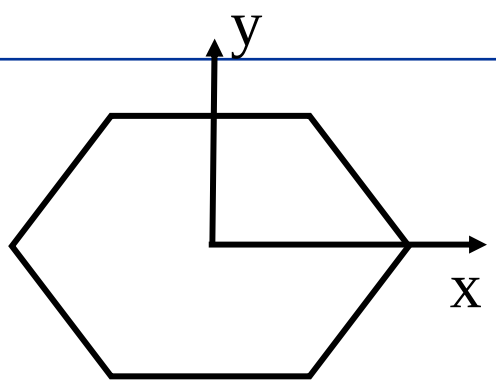


T^M = Primary Twin Twinning Reference Frame

C^M = Crystallographic Frame of Matrix

C^N = Crystallographic Frame of Neighbour Grain

$$e^{T^M} = \begin{pmatrix} 0 & 0 & \gamma \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \longrightarrow e^{C^N} = \begin{pmatrix} e_{xx} & e_{xy} & e_{xz} \\ e_{yx} & e_{yy} & e_{yz} \\ e_{zx} & e_{zy} & e_{zz} \end{pmatrix}$$



e_{xz} – single basal glide,
e_{yz} – double basal glide (easy)

e_{zx} – extension & contraction
e_{zy} twinning + <c + a> slip (relatively easy)

e_{xy} – single prismatic slip
e_{yx} – double prismatic slip (difficult & rate controlling)

e_{ij}: i- shear direction
j- shear plane

Accommodation strains in neighbor grain

Twinning shear

$$\begin{pmatrix} 0 & 0 & 0.138 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

Basal

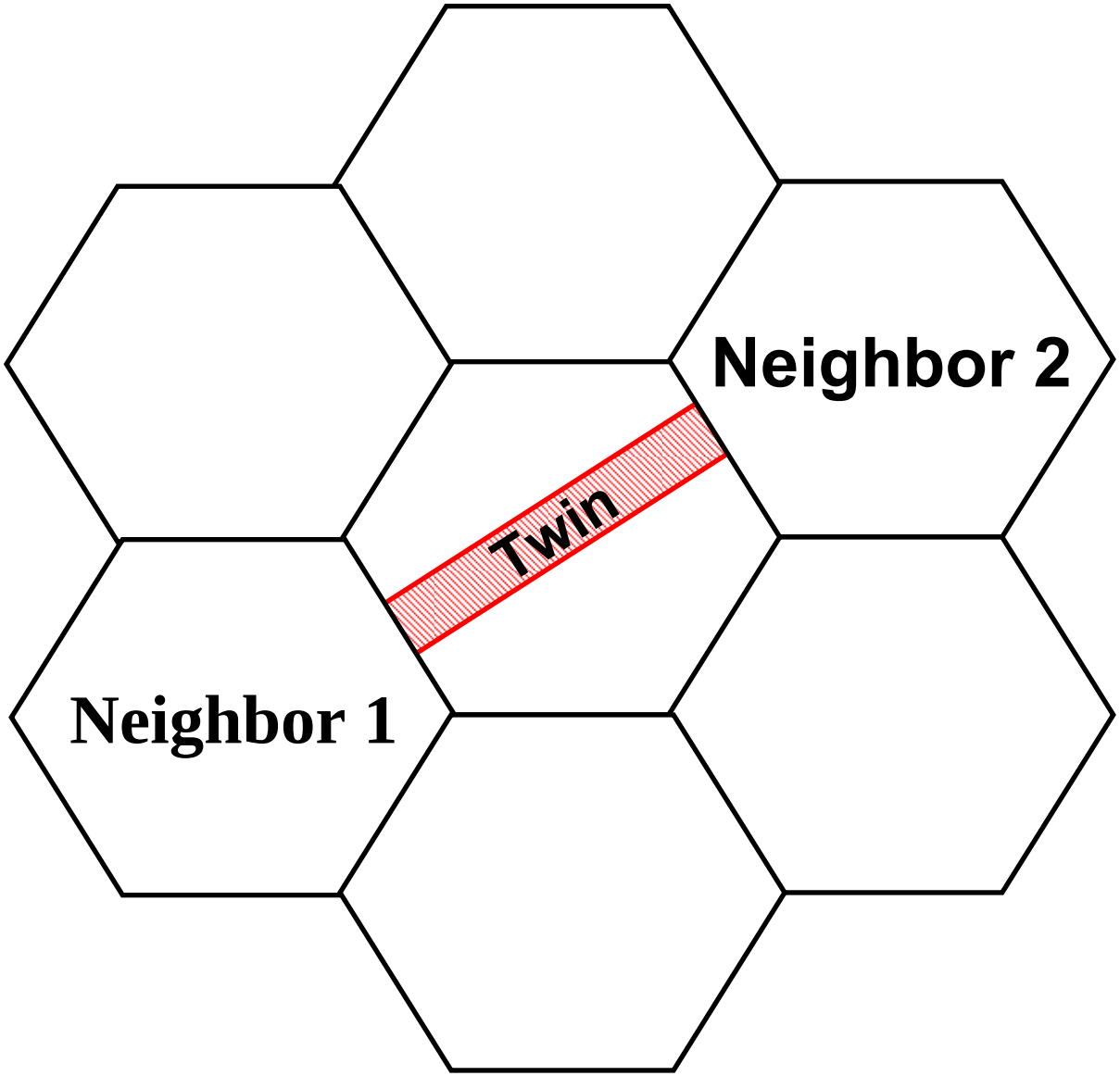
$$\begin{pmatrix} -0.0128 & -0.0541 & -0.1129 \\ 0.0056 & 0.0237 & 0.0495 \\ -0.0012 & -0.0052 & -0.0109 \end{pmatrix}$$

Twin/Py

$$\begin{pmatrix} 0.023 & -0.0597 & 0.0122 \\ 0.0001 & -0.0002 & -0.0000 \\ -0.0430 & 0.1116 & -0.0227 \end{pmatrix}$$

Prismatic

$$\begin{pmatrix} -0.0462 & 0.1128 & -0.0150 \\ -0.0205 & 0.0500 & -0.0066 \\ -0.0118 & 0.0290 & -0.0038 \end{pmatrix}$$


Neighbor 2
Twin
Neighbor 1

Accommodation strains in neighbor grain

Twinning shear

$$\begin{pmatrix} 0 & 0 & 0.138 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

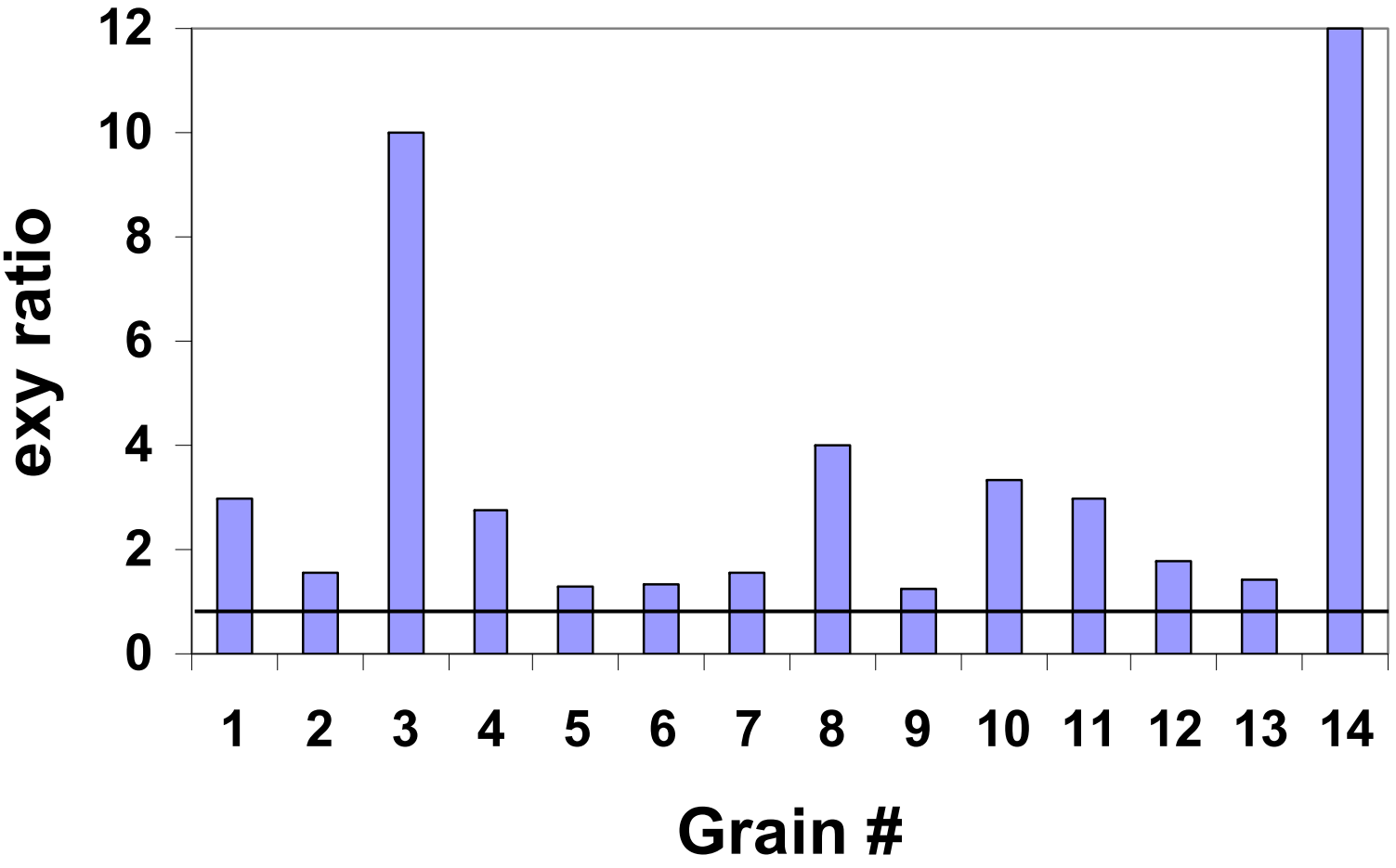
Selected **SF: 0.104**

$$\begin{pmatrix} -0.0348 & -0.0073 & 0.0075 \\ 0.0415 & 0.0087 & -0.009 \\ -0.1205 & -0.0252 & 0.0261 \end{pmatrix}$$

Unselected **SF: 0.415**

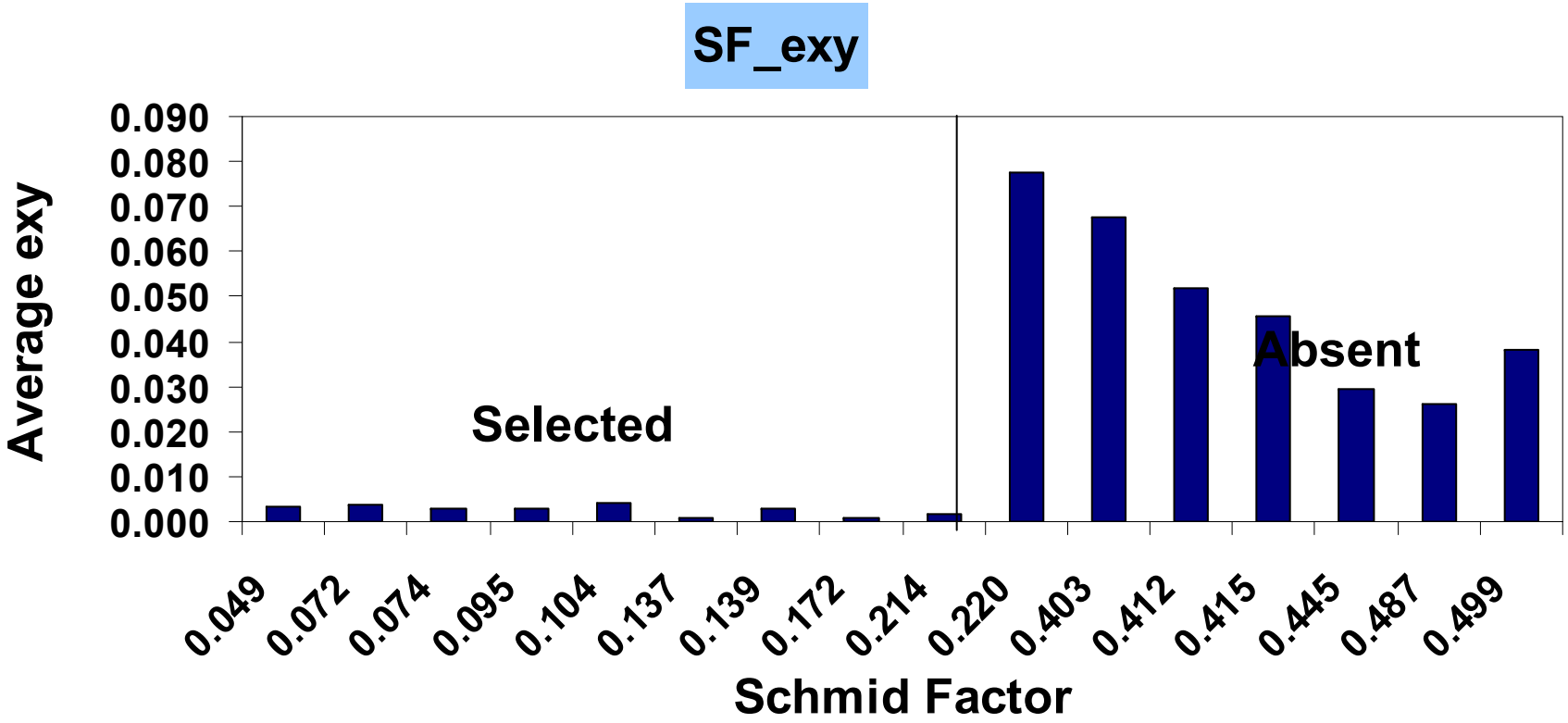
$$\begin{pmatrix} -0.0093 & 0.0938 & -0.0333 \\ -0.0038 & 0.0379 & -0.0135 \\ -0.0080 & 0.0808 & -0.0286 \end{pmatrix}$$

$$\text{Ratio} = e_{xy}^{\text{absent}} / e_{xy}^{\text{selected}}$$

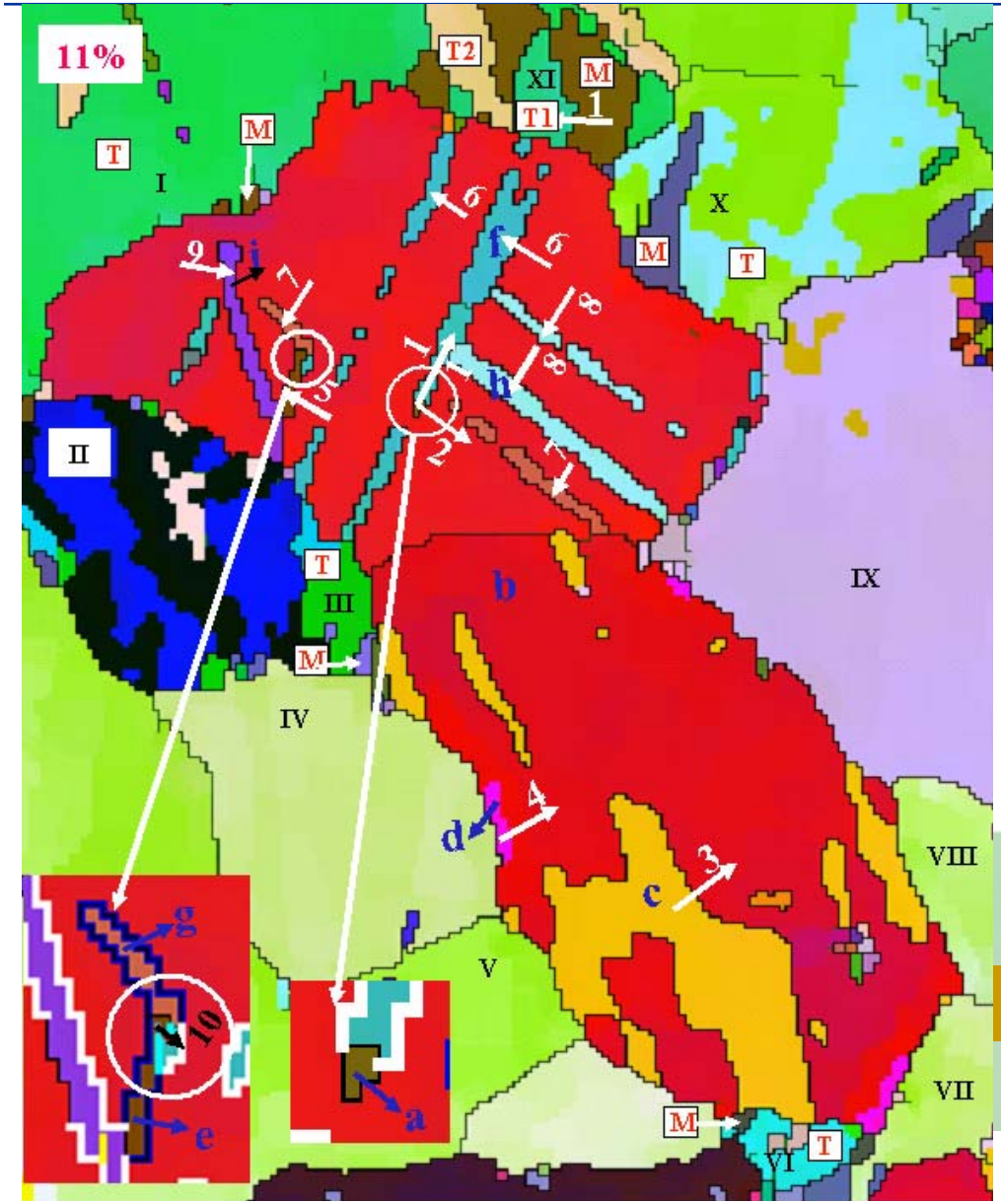


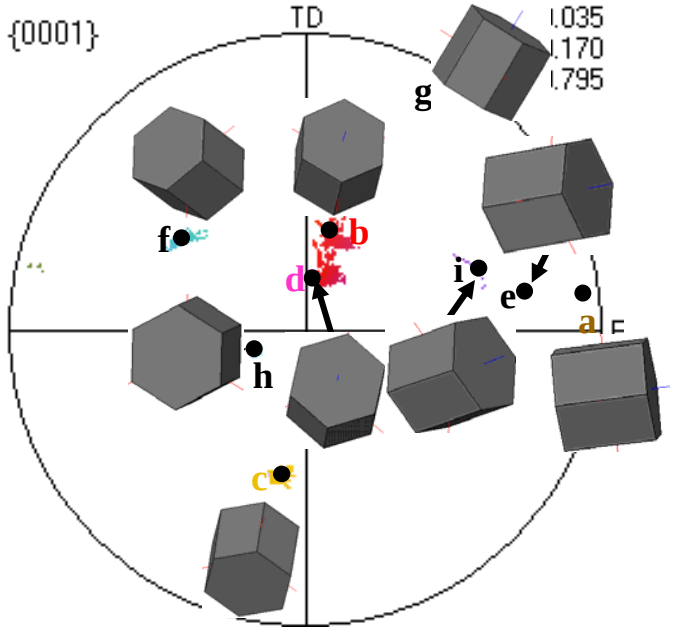
144 matrix/neighbor pairs in simulation

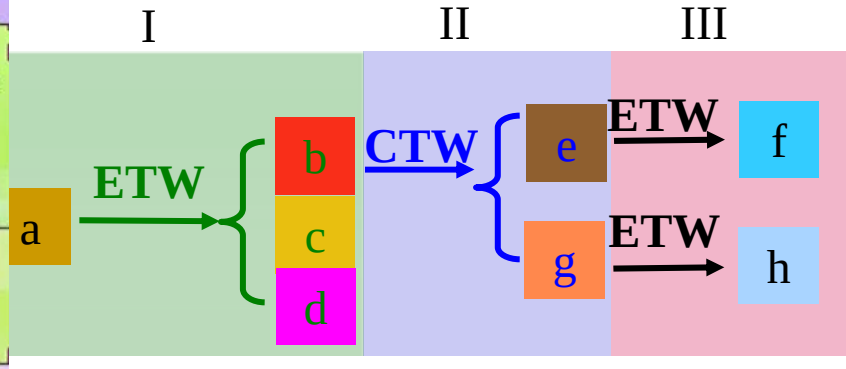
Simulation Results for 44 matrix/neighbor pairs



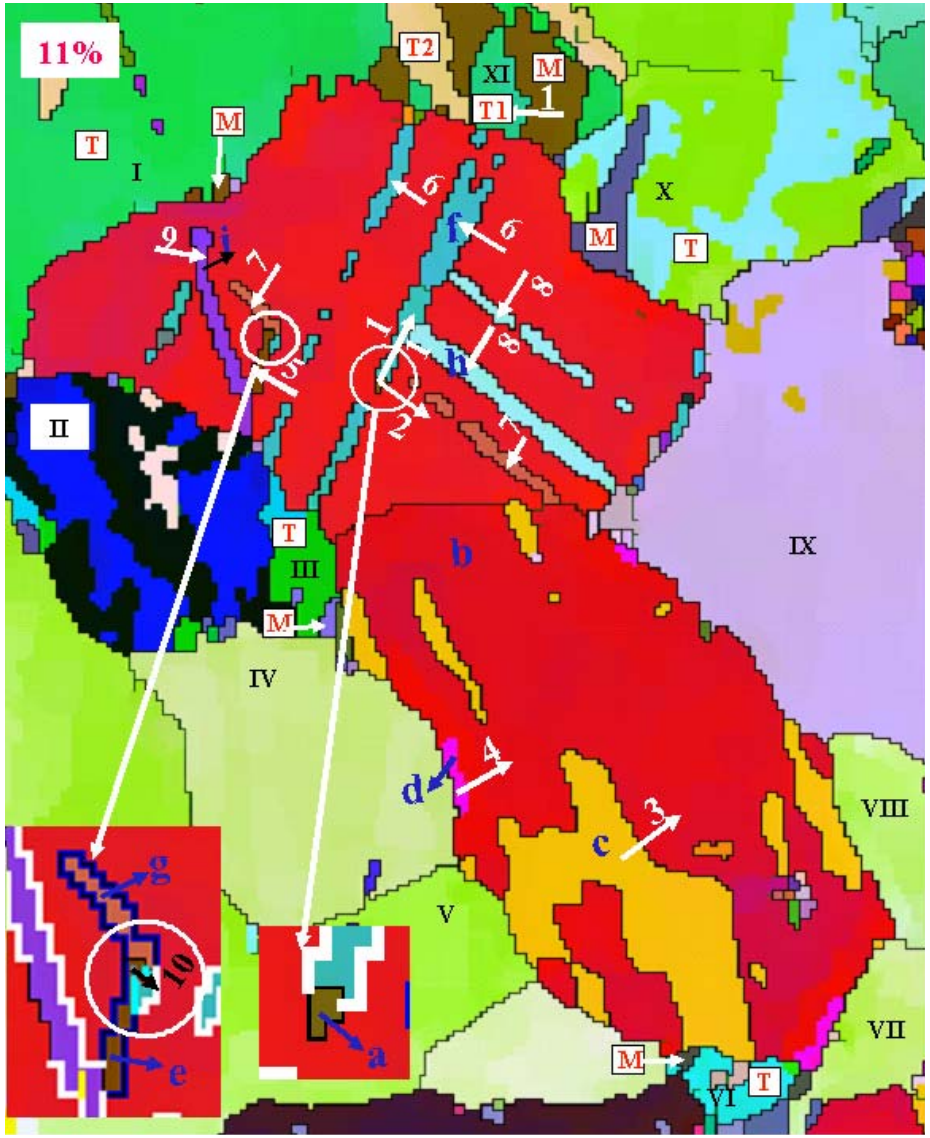
Analysis of twin generations based on misorientation relationship

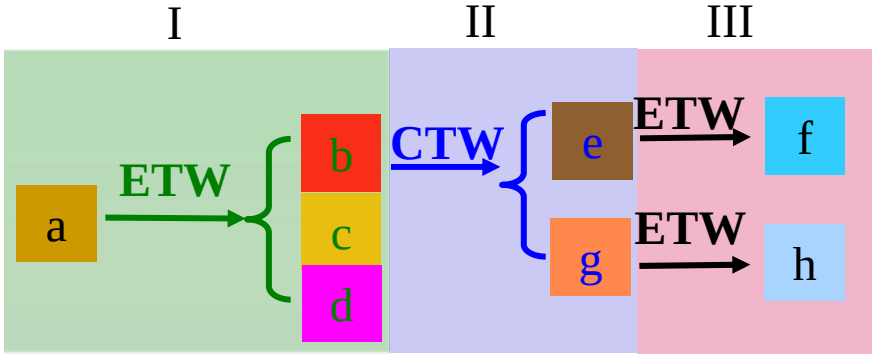


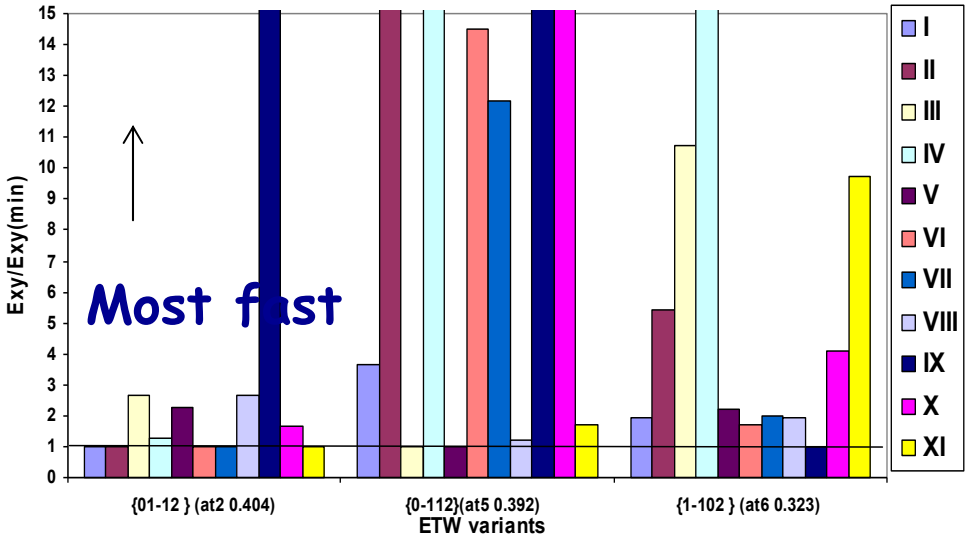




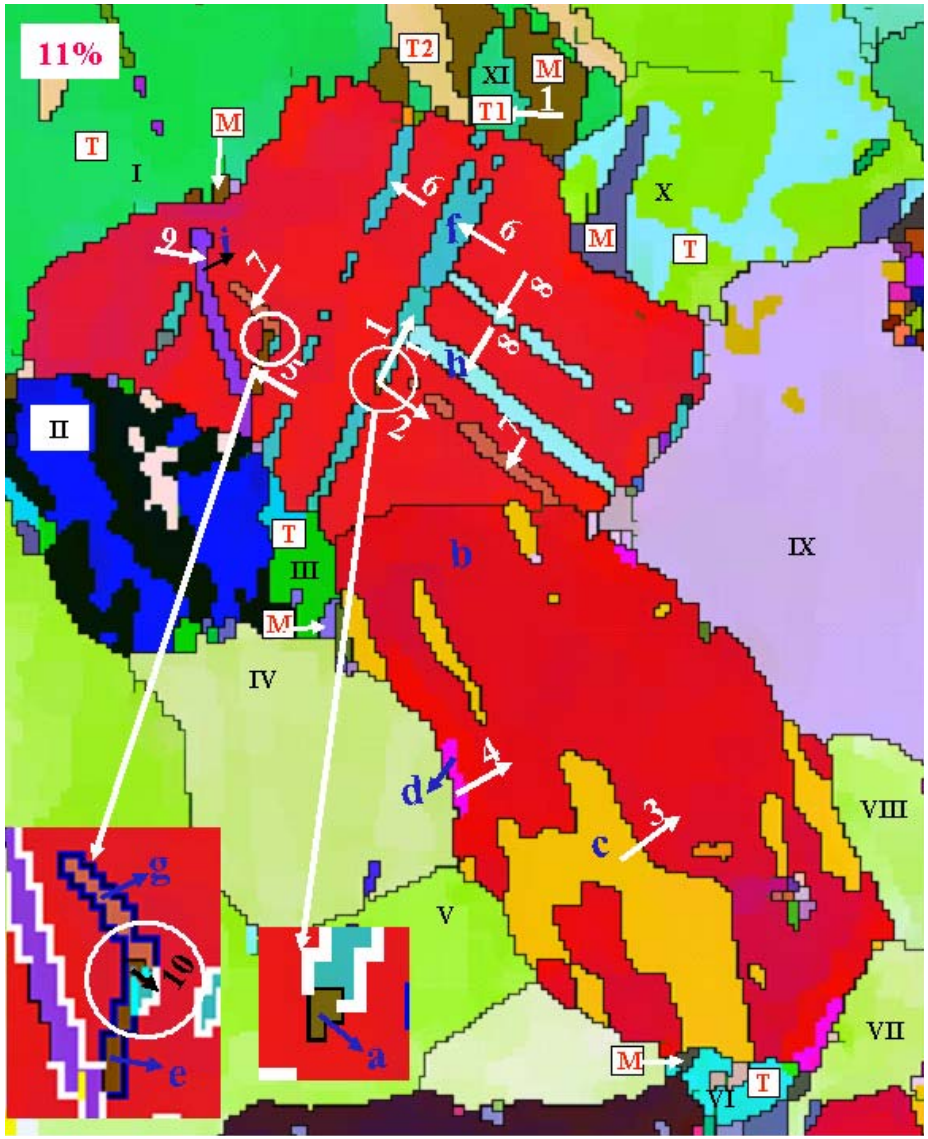
Growth of Primary Extension Twin

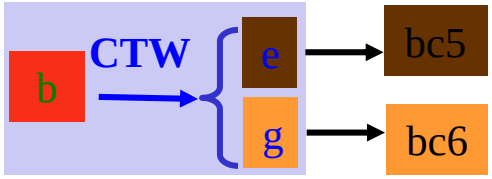




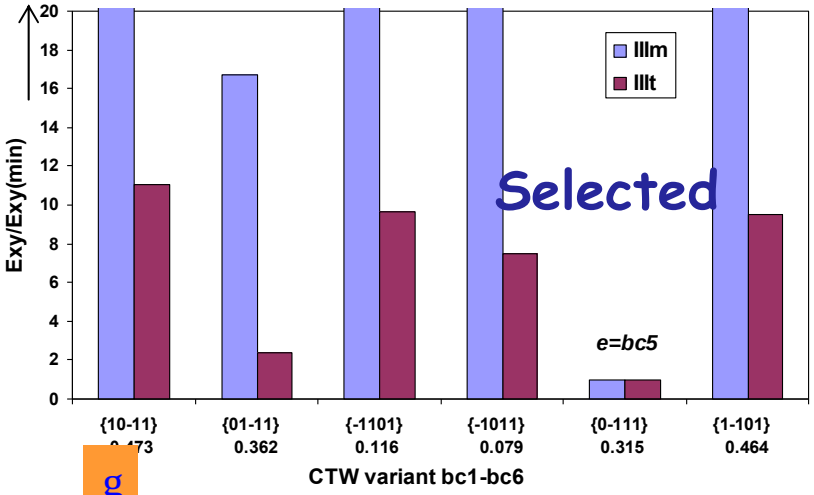


Nucleation of Secondary Contraction Twin





e



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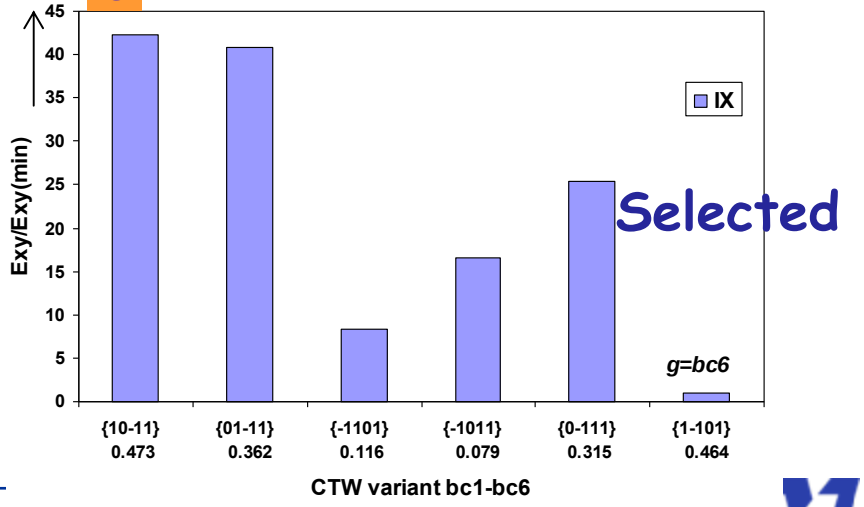
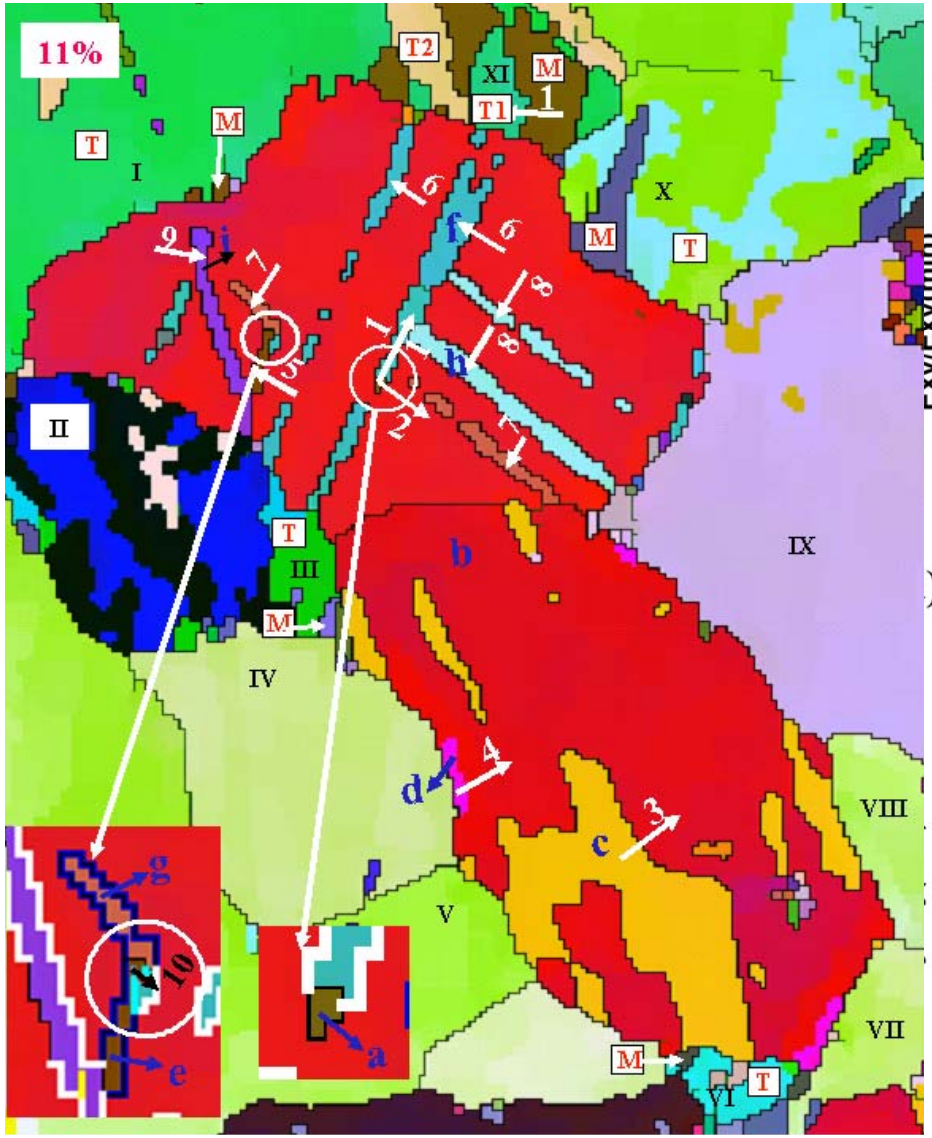
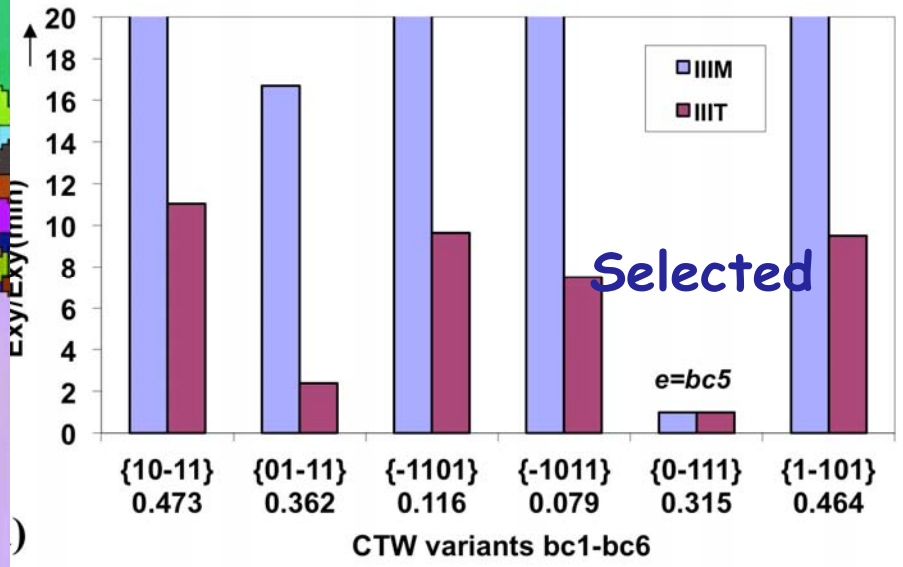
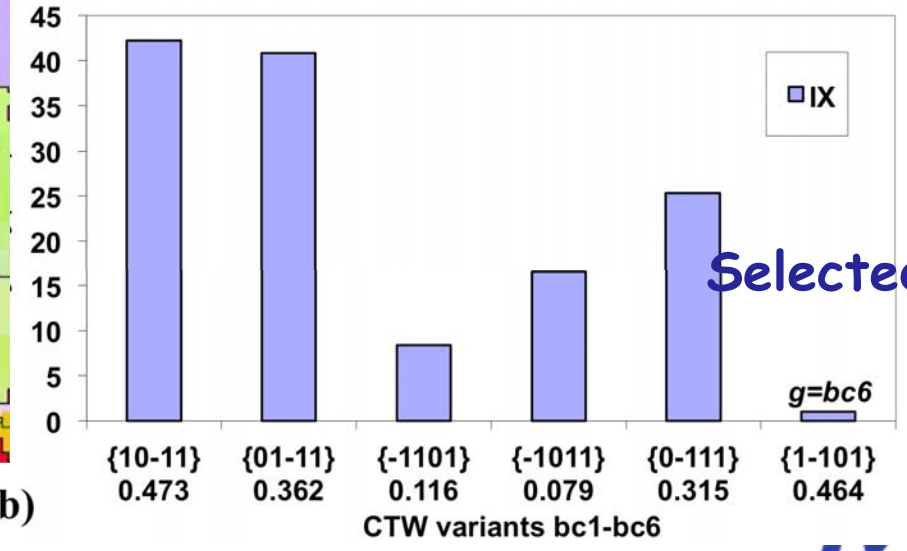


Nucleation of tertiary ETW

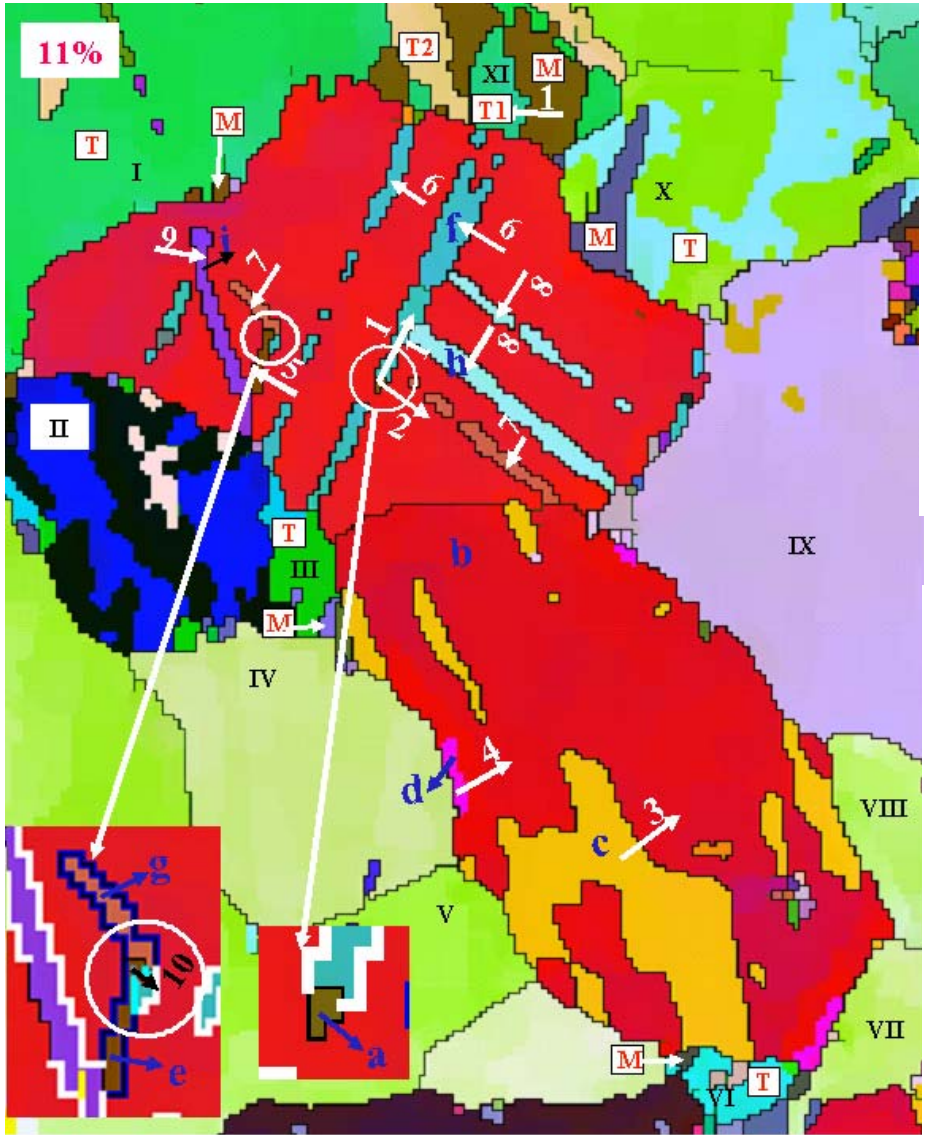


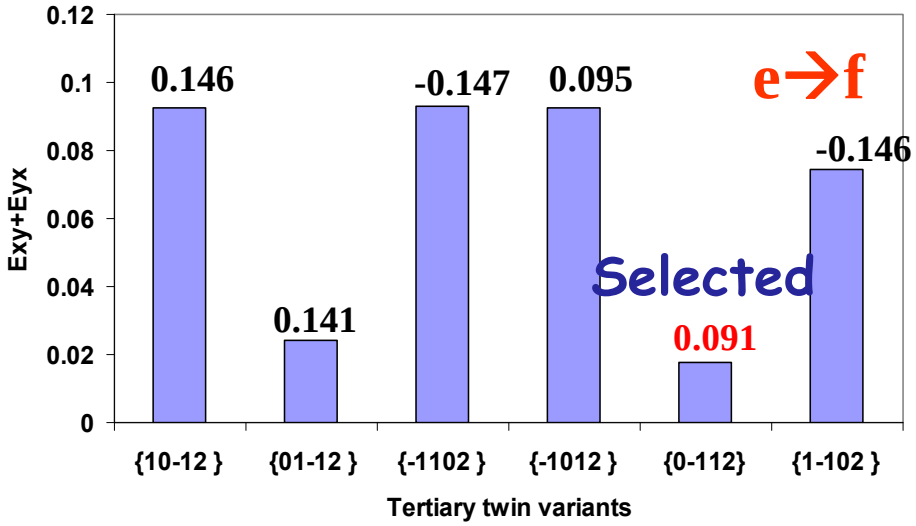
(b)

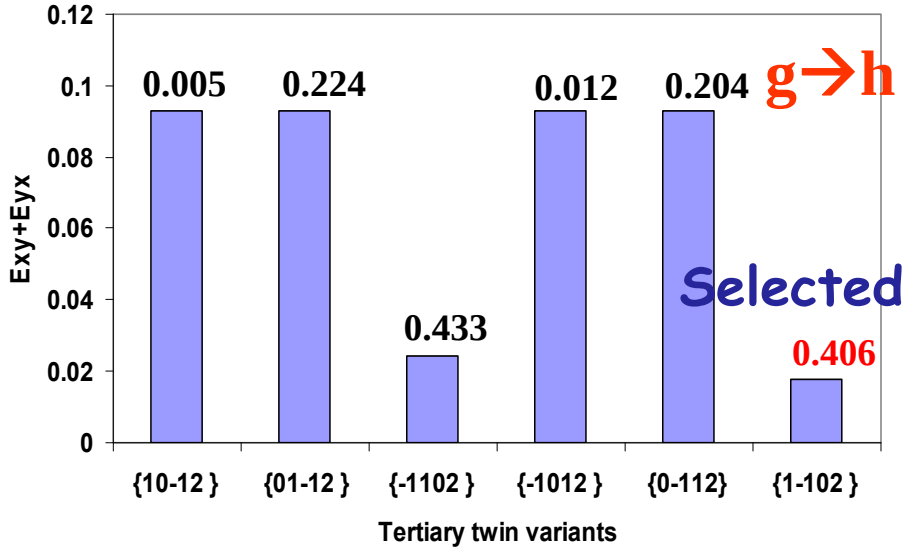




Nucleation of Tertiary Extension Twin







Conclusions

1. **The accommodation strain that a twin tries to impose on its neighboring grain can be calculated by translating the displacement gradient tensor of twinning from twin system frame into the crystal frame of the neighboring grain.**

2. **Each of the accommodation strain tensor components can be given a physical interpretation in terms of slip or twinning. e_{xy} and e_{yx} are difficult components.**

3. **The twin variants requires easy glide or twinning (low e_{xy} and e_{yx}) in the neighboring grain will be activated even if its SF is low.**

4. **A variant demands activation of difficult slip (Pr, high e_{xy} and e_{yx}) not active.**


Thank you for your attention