



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Dipartimento di Geoscienze

Tesi di Laurea Triennale in Scienze Geologiche



RELAZIONI DI CRESCITA TRA MAGNESIOCROMITE E DIAMANTI: IMPLICAZIONI SULLA SINGENESI/PROTOGENESI

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Un nuovo contributo ad un grande dibattito

✓ **COSA?** Verifica **crescita epitassiale**
magnesiocromite-diamante

✓ **COME?** Approccio cristallografico
Analisi sistematica

✓ **PERCHÈ?**

Ricostruzione **meccanismi**
di **crescita inclusione-**
diamante

01 - Diffrazione a RX
a cristallo singolo

02 - Relazioni di
orientazione
cristallografica

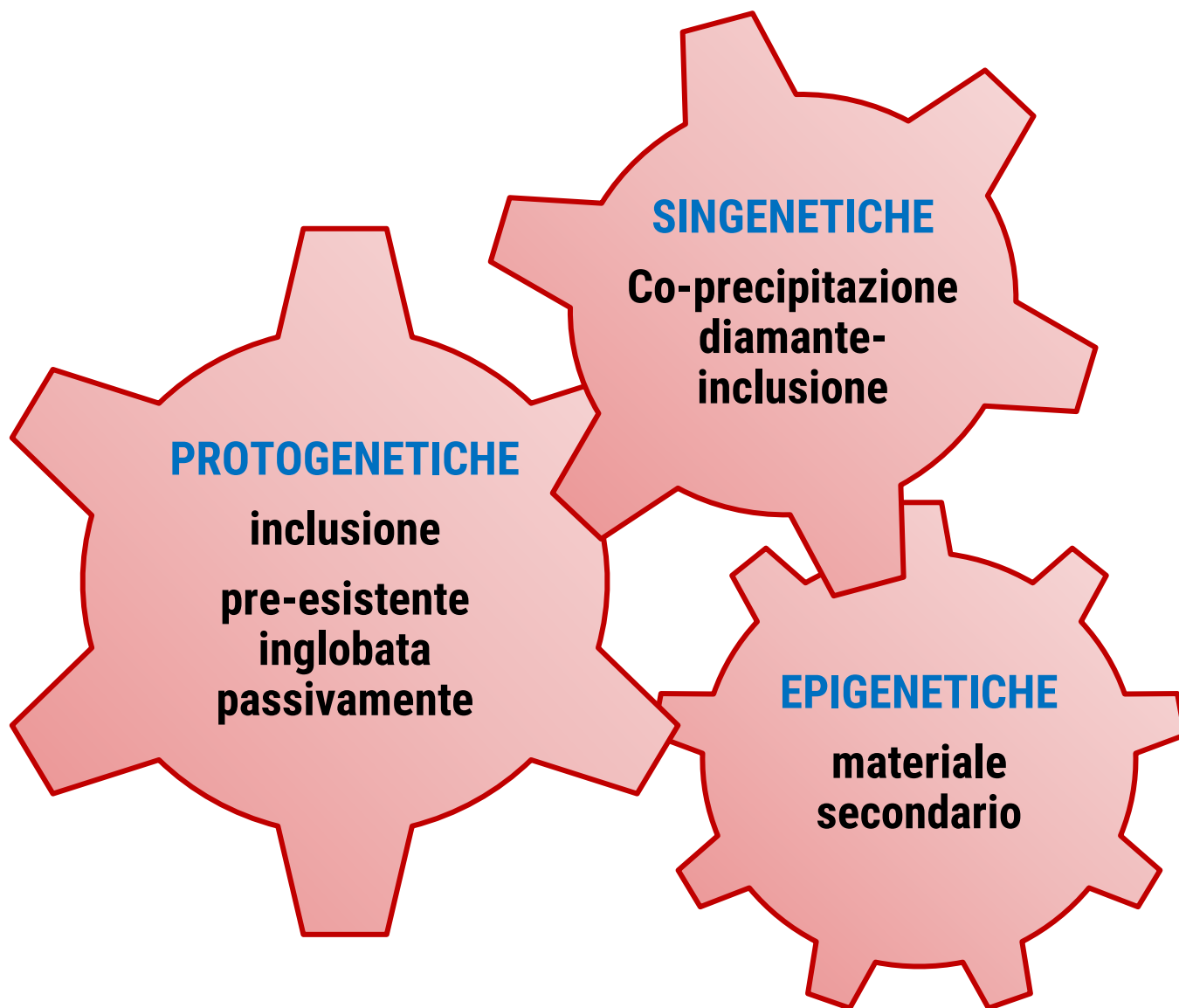
03 - Singenesi o
Protogenesi?



Singenesi o Protogenesi?

Key issue:

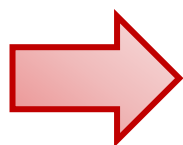
- ✓ Quando si è formata l'inclusione?
- ✓ Come si è verificato l'intrappolamento?



Evidenze in favore della SINGENESI

Assunto: La maggior parte delle **inclusioni** nei diamanti sono **singenetiche**

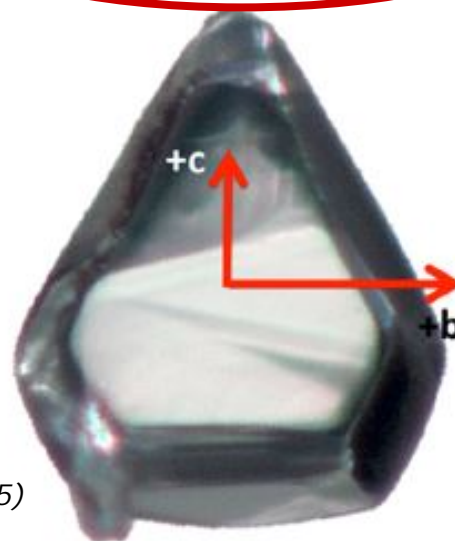
- ✓ Mitchell and Giardini, 1953;
- ✓ Futergendler & Frank-Kamenetsky, 1961;
- ✓ Frank-Kamenetsky 1964



(a) Morfologia imposta dal diamante
(cubo-ottaedro) – Harris (1968)

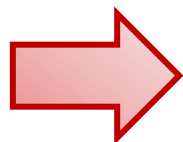
Typical cubo-octahedral shape imposed by diamond on olivine

Typical morphology of natural olivine



Nestola (2015)

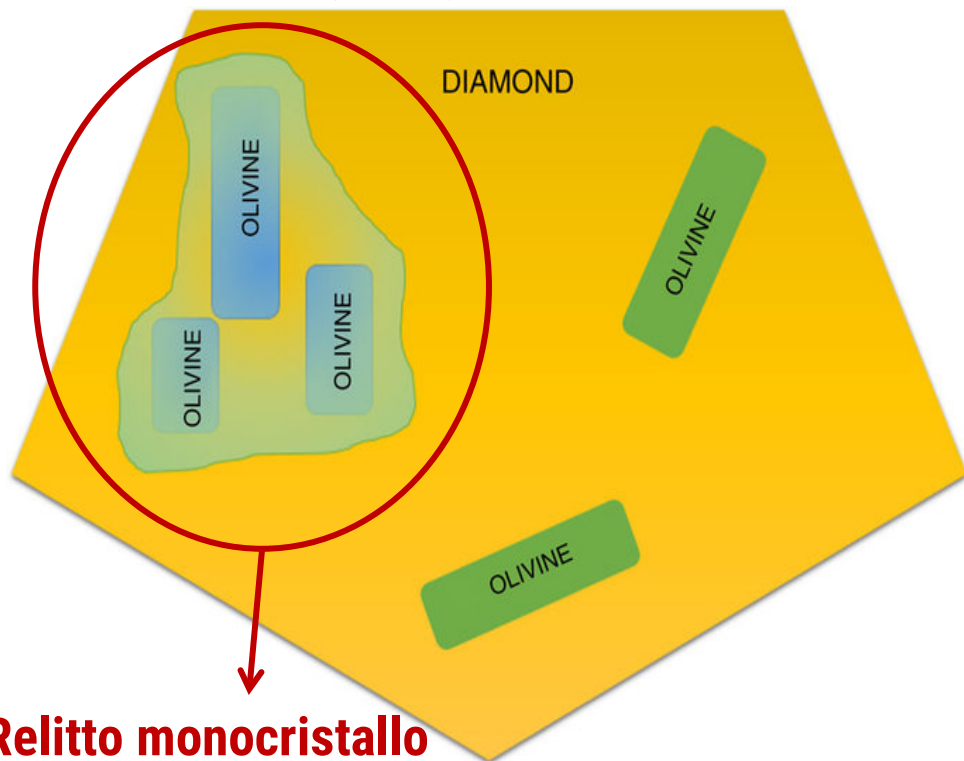
(?)



(b) Epitassia: coincidenza piani e/o direzioni cristallografiche inclusione-diamante

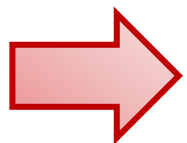
Evidenze in favore della PROTOGENESI (1)

Nestola et al. (2017)



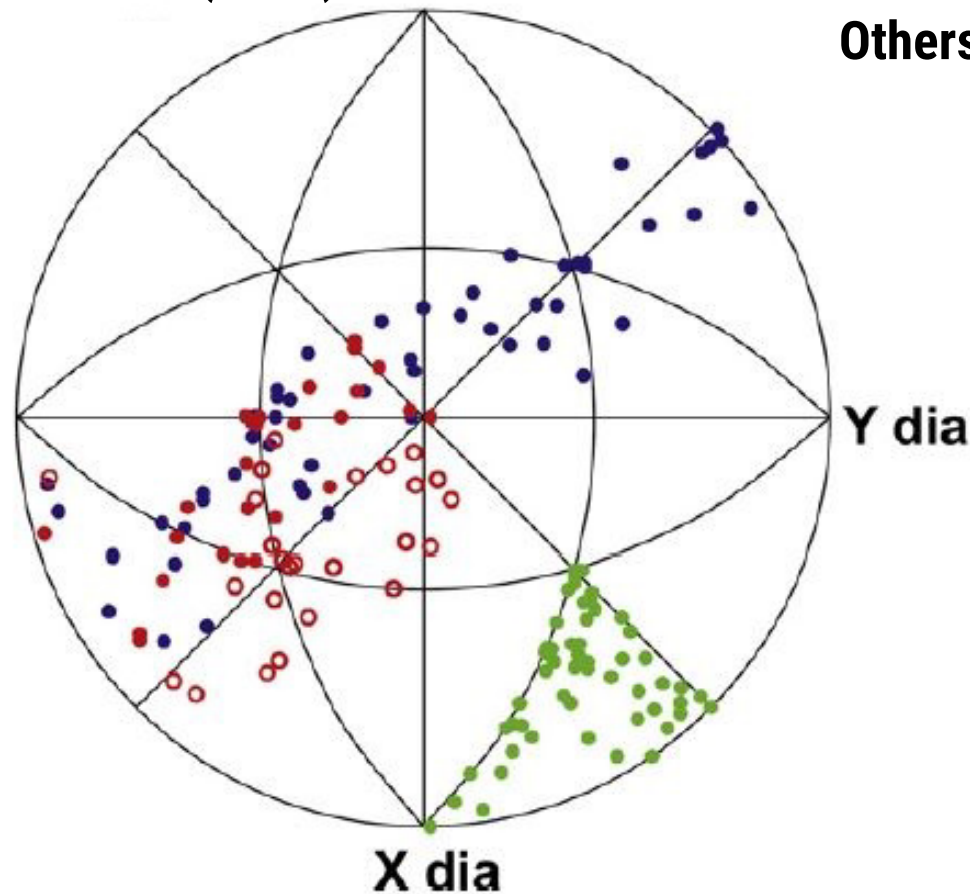
Relitto monocristallo originario

✓ **Gruppi olivina in singolo diamante
SIMILE orientazione**



Olivine protogenetiche!

Nestola et al. (2014)
Milani et al. (2016)



Kaapvaal
Siberian Craton
Others

✓ **ASSENZA orientazioni
cristallografiche preferenziali**



E la MAGNESIOCROMITE?

- ✓ Inclusione **diamanti litosferici**
- ✓ Affinità peridotitica

Data set limitato:

- ✓ Frank Kamenetsky (1964)
- ✓ Wiggers de Vries (2011)

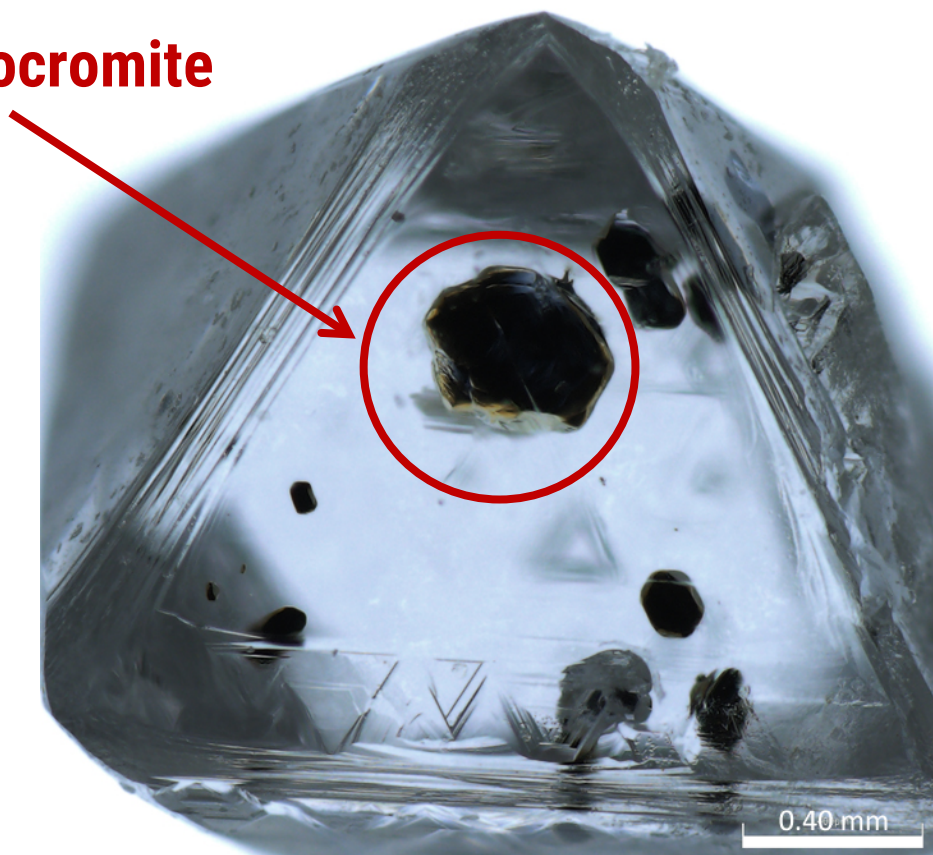


SINGENESI (?)

**Primo studio sistematico
relazioni cristallografiche
magnesiocromite vs diamante!**



magnesiocromite



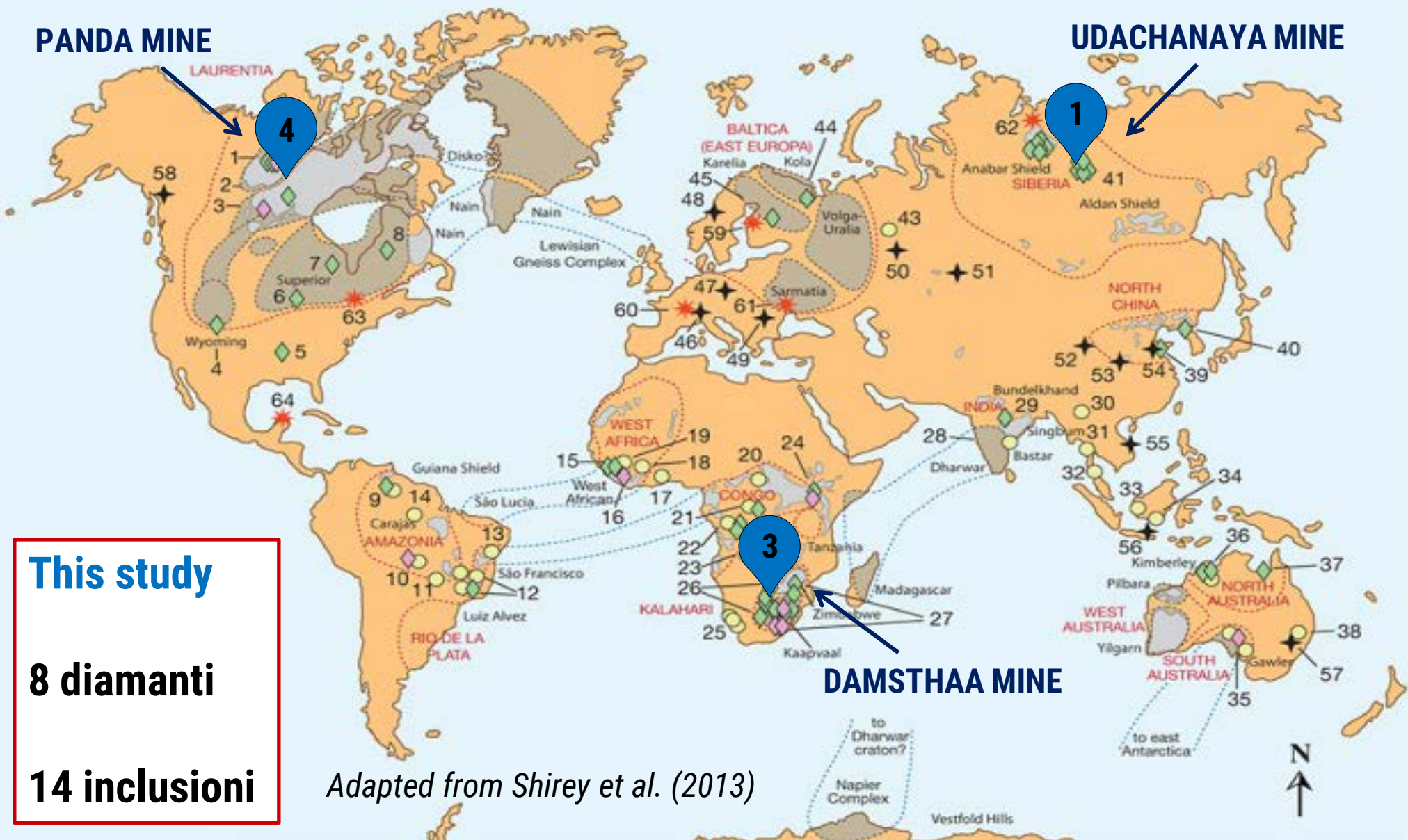
This study		Others(Udachnaya)
8 diamanti	+	15 diamanti
14 inclusioni		21 inclusioni



Materiali in studio: contesto geografico

PANDA MINE

UDACHANAYA MINE

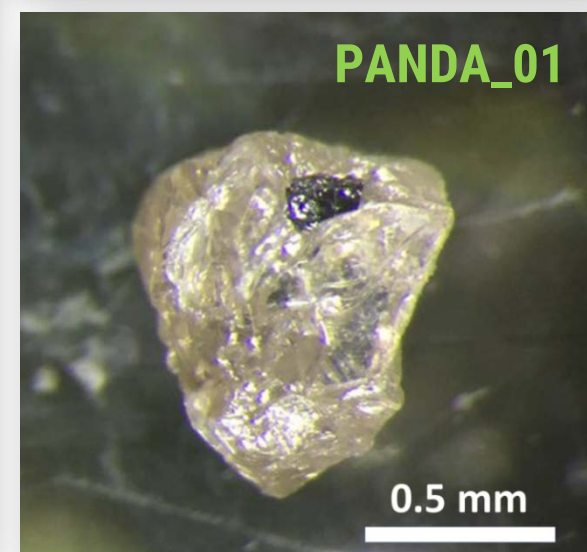
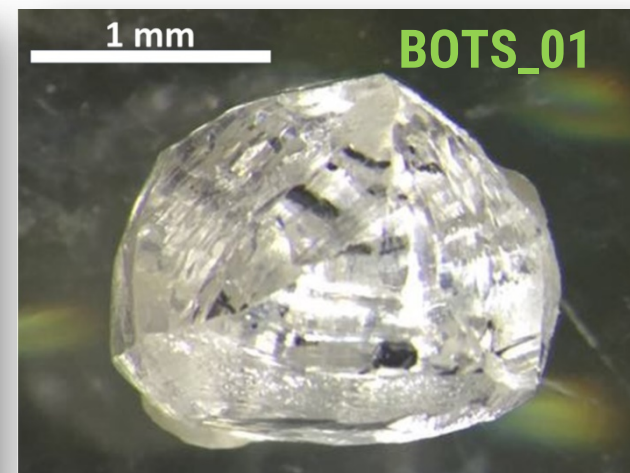
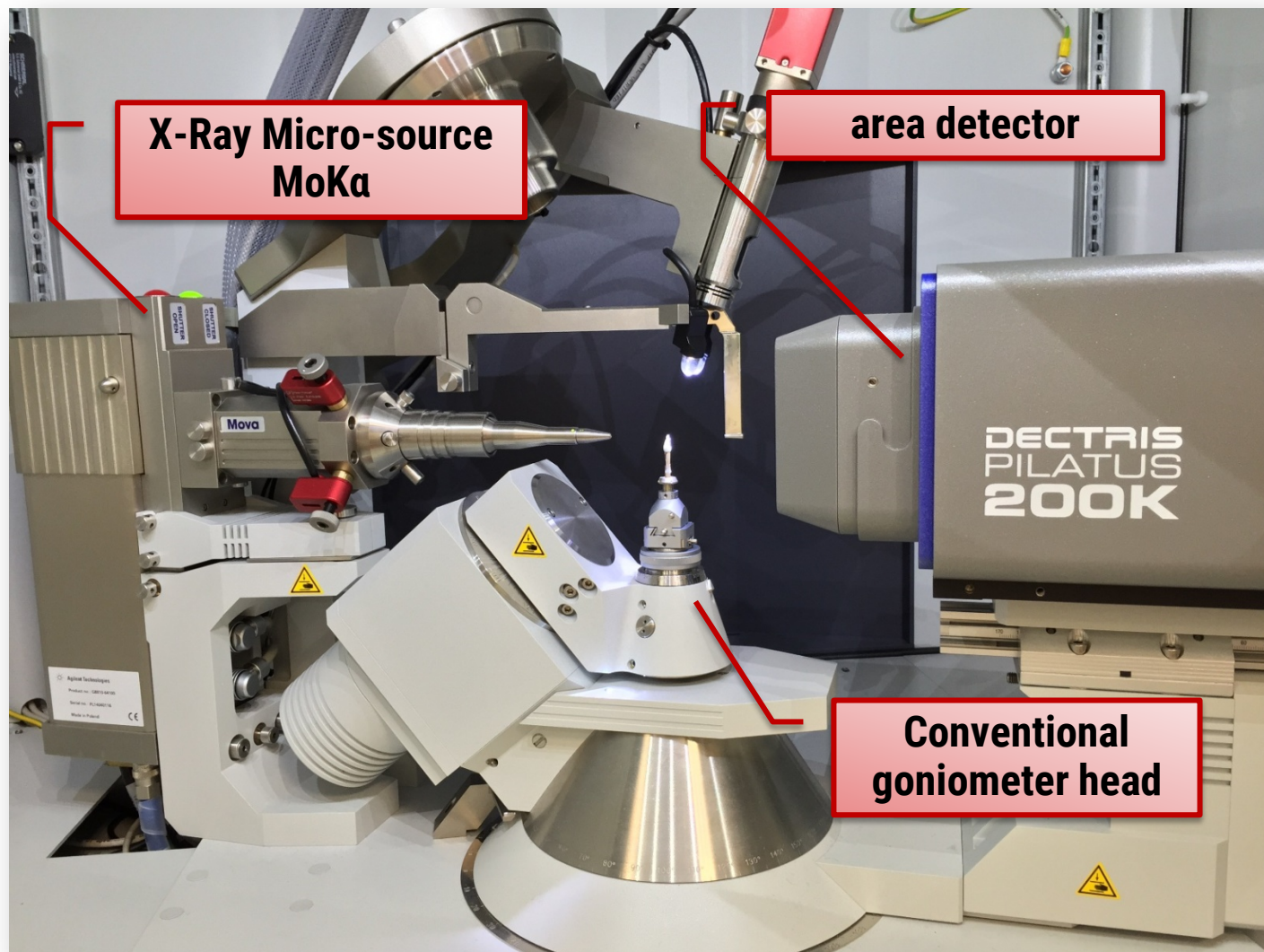


This study
8 diamanti
14 inclusioni

Adapted from Shirey et al. (2013)



Metodo sperimentale: Diffrazione a RX a cristallo singolo





Metodo di calcolo: OrientXplot (1)

Dalla **matrice di orientazione (INPUT)** alle **relazioni di orientazione cristallografica (OUTPUT)**

Original orientation matrix read from input file

Grp	N	IUse	Host	Inclusion
1	1	1	DIAMOND BOTS_01	MGCR BOTS_01_01
			(-0.08884 0.17264 0.03401)	(0.05808 0.02273 0.05796)
			(0.09121 0.07982-0.15308)	(-0.01736-0.07027 0.04490)
			(-0.14651-0.05640-0.11372)	(0.05989-0.04240-0.04324)
1	2	1	DIAMOND BOTS_01	MGCR BOTS_01_02
			(-0.08884 0.17264 0.03401)	(-0.06585 0.05048-0.02350)
			(0.09121 0.07982-0.15308)	(-0.04458-0.02544 0.06880)
			(-0.14651-0.05640-0.11372)	(0.03375 0.06451 0.04561)

HOST

GUEST

UB matrix
diamante (HOST)-
inclusione (GUEST)

The options for LIST are:



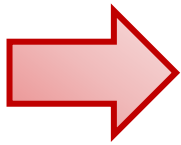
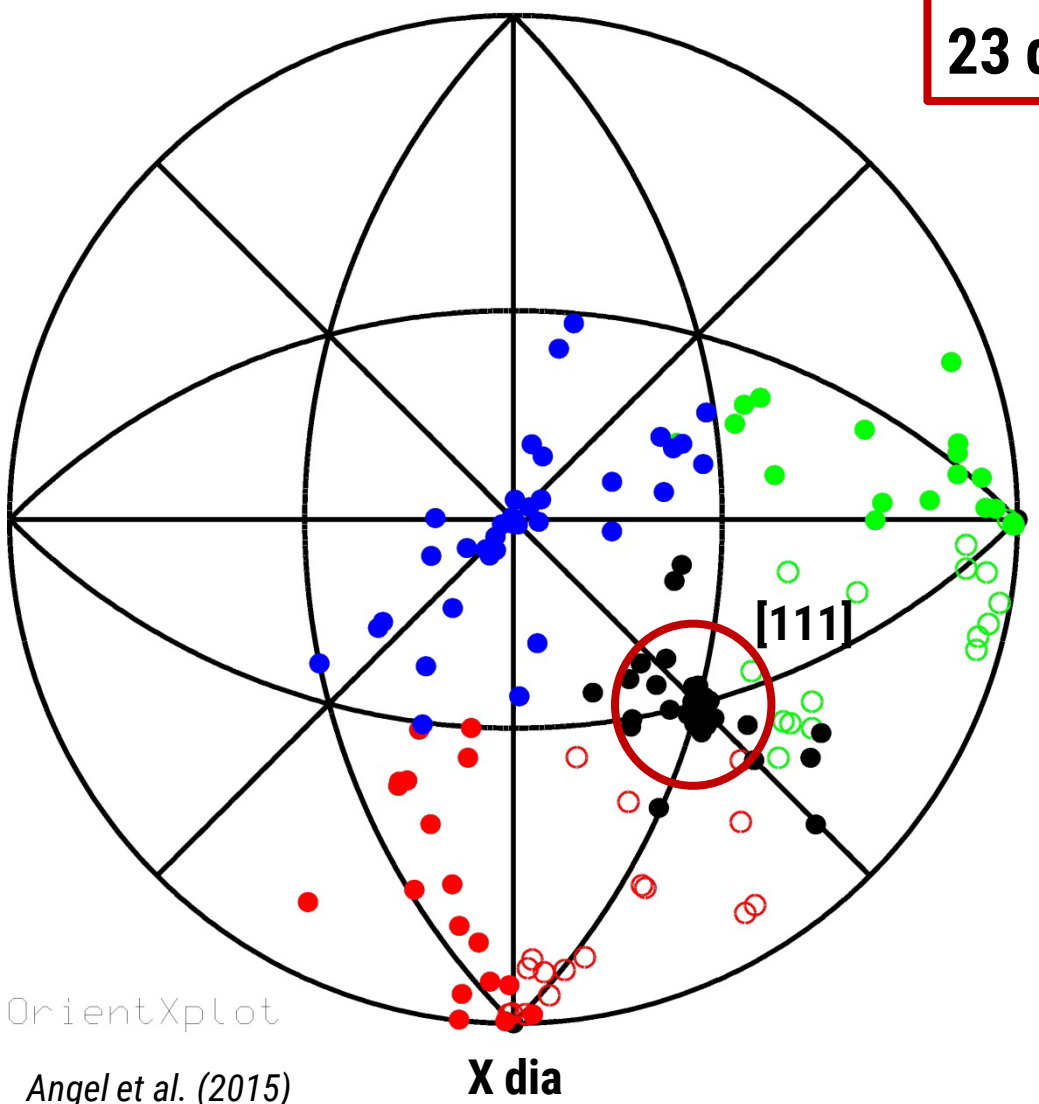
Orientazione cristallografica tra magnesiocromite e diamante (1)

(a) All available data

35 inclusioni
23 diamanti

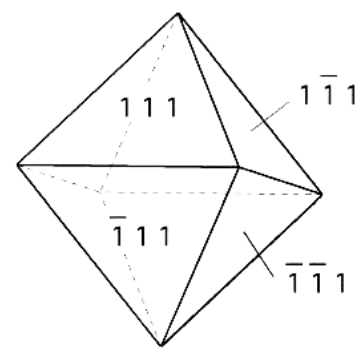
Sono evidenti orientazioni cristallografiche preferenziali?

Cluster (111) inclusioni vs (111) diamante



Y dia

- (100) piano normale inclusi
- (010) piano normale inclusi
- (001) piano normale inclusi
- (111) piano normale inclusi vuoti plot emisfero inferiore



{111} (octahedron)

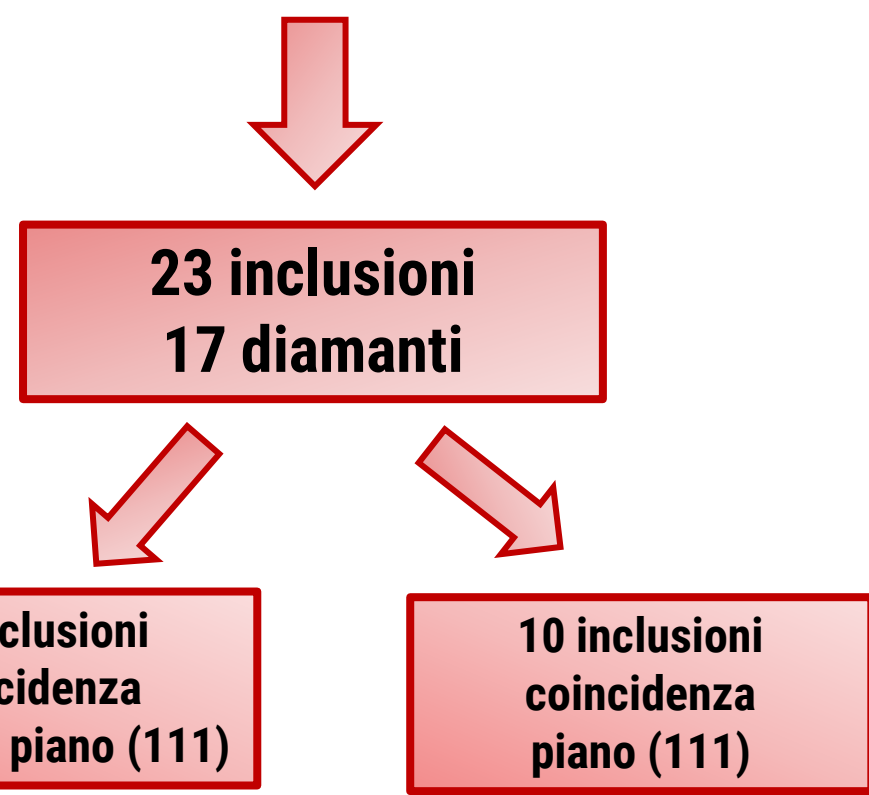
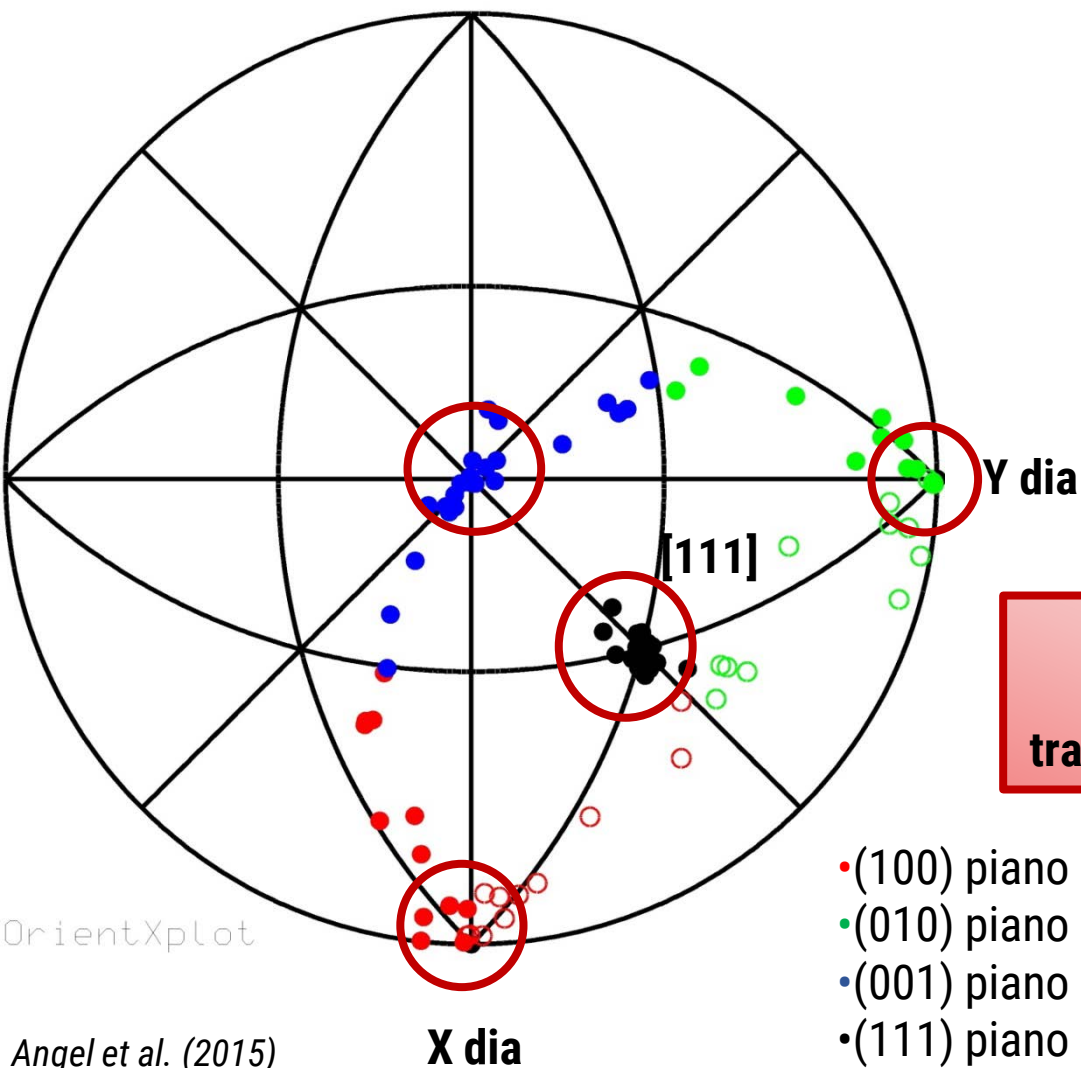
(?)

OrientXplot
Angel et al. (2015)



Orientazione cristalografica tra mg-cromite e diamante(2)

(b) All available data with (111) magnesiochromite \wedge (111) dia $\leq 10^\circ$



- (100) piano normale inclusi
- (010) piano normale inclusi
- (001) piano normale inclusi
- (111) piano normale inclusi
- vuoti plot emisfero inferiore

OrientXplot
Angel et al. (2015)



Qual è l'orientazione della magnesiocromite rispetto al diamante?

(a) **SIMILE** orientazione tra **assi principali e piano (111)** - entro 10°

37%

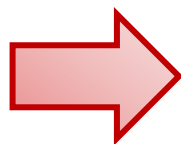
(b) **CONDIVIDE** almeno il **piano (111)** con il diamante - entro 10°

29%

(c) **Orientazione CASUALE** rispetto al diamante

34%

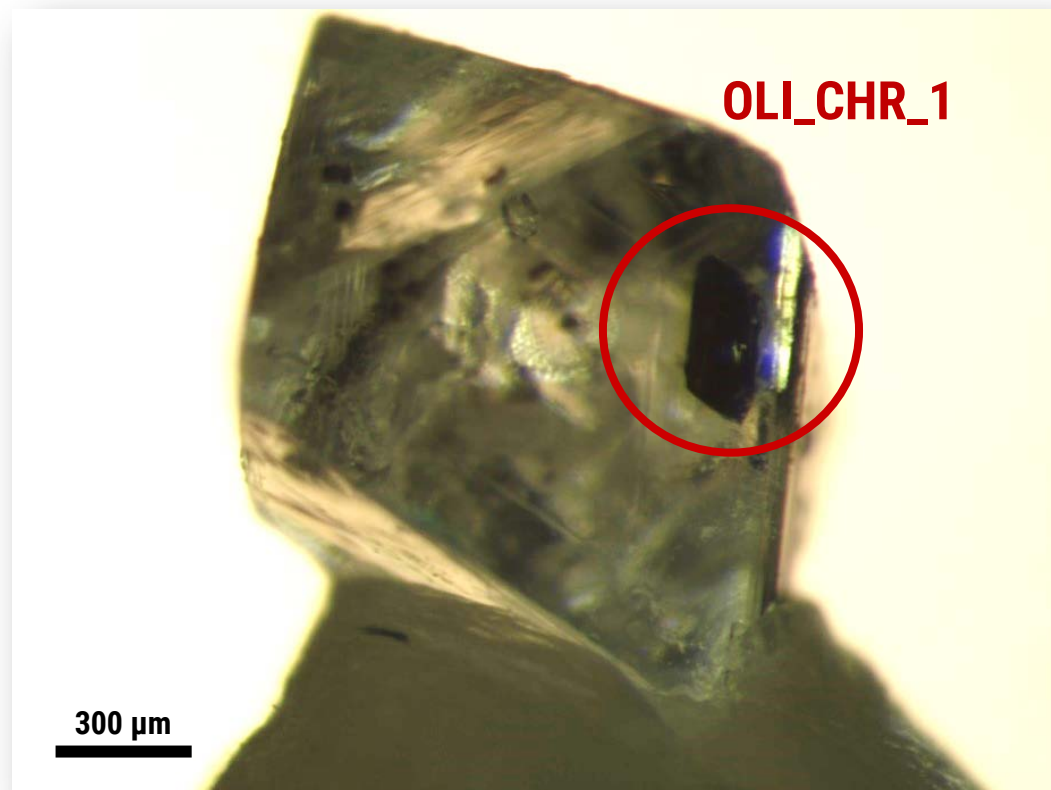
(a) **37% orientazione
cristallografica
preferenziale**



(1) Epitassia

- (1a) Il diamante ha agito da substrato
- (1b) La magnesiocromite ha agito da substrato

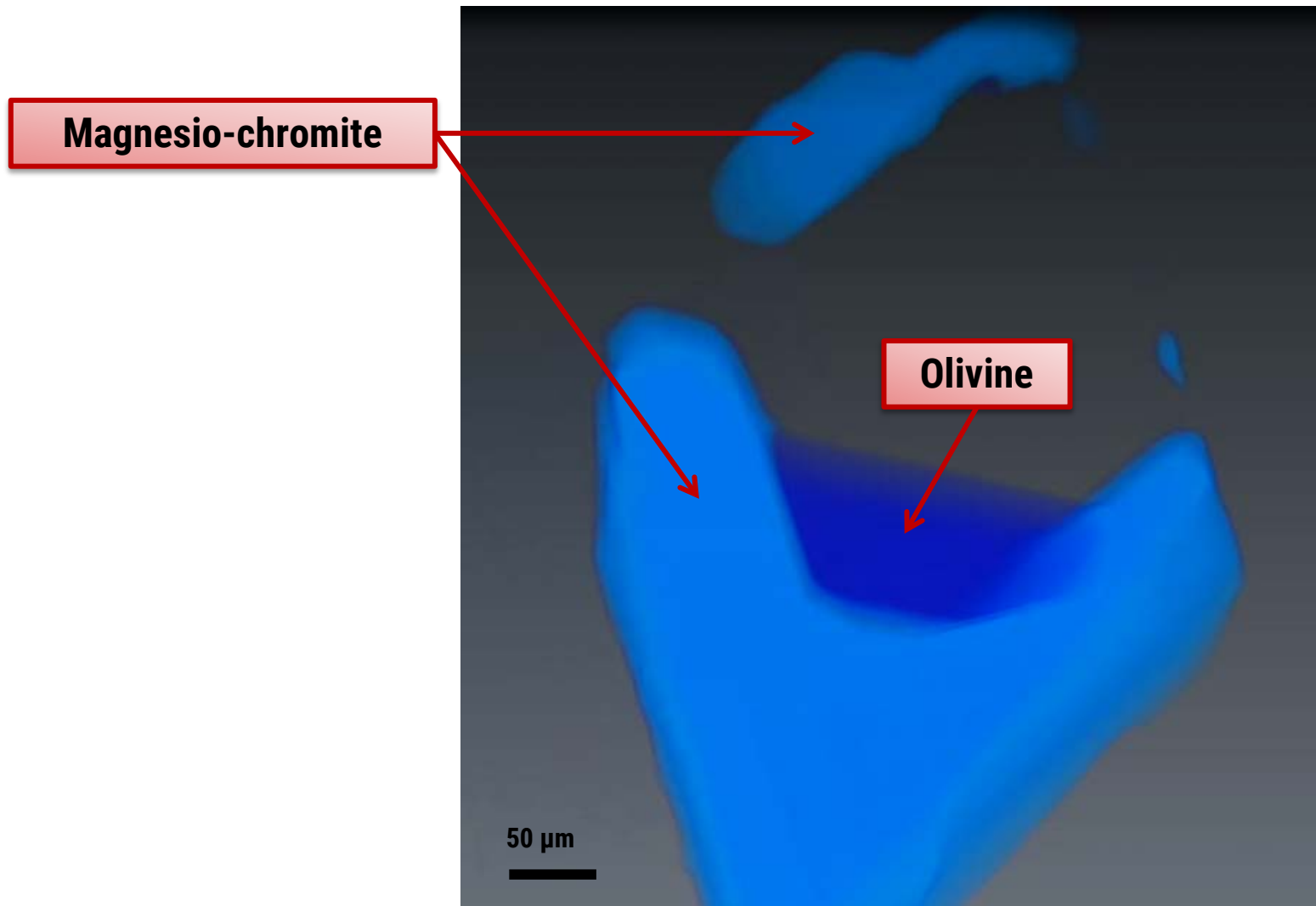
**Inclusioni in posizione marginale
sfavoriscono (1b)**

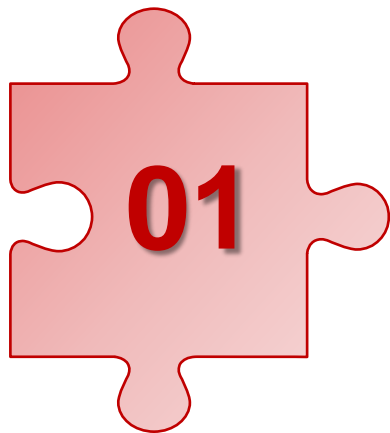
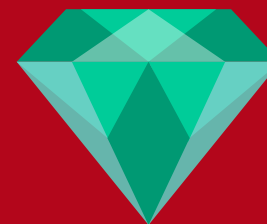


**(2) Questa evidenza sperimentale
esclude la protogenesi ma non la
singenesi**



Risultati (3): OLI_CHR_1 - Udachanaya mine (Siberia)





Non è escluso, che le magnesiocromiti con orientazione preferenziale rispetto al diamante, si siano formate durante la storia di crescita del diamante



Data la posizione periferica e la specifica orientazione cristallografica rispetto al diamante, per la maggior parte delle magnesiocromiti, si può escludere la protogenesi



- Angel, R.J., Milani, S., Alvaro, M., Nestola, F., 2015. OrientXplot: a program to analyse and display relative crystal orientations. *Journal of Applied Crystallography* 48, 1330–1334.
- F Nestola, H Jung, LA Taylor
Mineral inclusions in diamonds may be synchronous but not syngenetic; *Nature communications* 8
- Frank-Kamenetsky, V.A., 1964. *The Nature of Structural Impurities and Inclusions in Minerals*. Gos. Univ, Leningrad (in Russian).
- Griffiths, T.A., Habler, G., Abart, R. (2016): Crystallographic orientation relationships in host–inclusion systems: New insights from large EBSD data sets. *Amer. Miner.*, 101, 690–705.
- Jacob D.E., Piazzolo S., Schreiber A., Trimby P.
Redox-freezing and nucleation of diamond via magnetite formation in the Earth's mantle (2016). *Nature Communications*, 7, art. no. 11891
- Milani, S., Nestola, F., Angel, R. J., Nimis, P. & Harris, J. W. Crystallographic orientations of olivine inclusions in diamonds. *Lithos* (2016).
- Nestola, F., Nimis, P., Angel, R.J., Milani, S., Bruno, M., Prencipe, M., Harris, J.W., 2014. Olivine with diamond-imposed morphology included in diamonds. Syngenesism or protogenesism? *International Geology Review* 56, 1658–1667.
- Stachel, T., and Harris, J.W., 2008, The origin of cratonic diamonds
– Constraints from mineral inclusions: *Ore Geology Reviews*, v. 34, p. 5–32. doi:10.1016/j.oregeorev.2007.05.002
- The crucial role of crystallography in diamond research; F Nestola *Rendiconti Lincei* 26 (2), 225-233
- Wiggers de Vries D.F. et al., *Contrib Mineral Petr* 161, 565-579 (2011).