1- Dalla pietra ai ceramici avanzati

- Materiali Litici e Lapidei

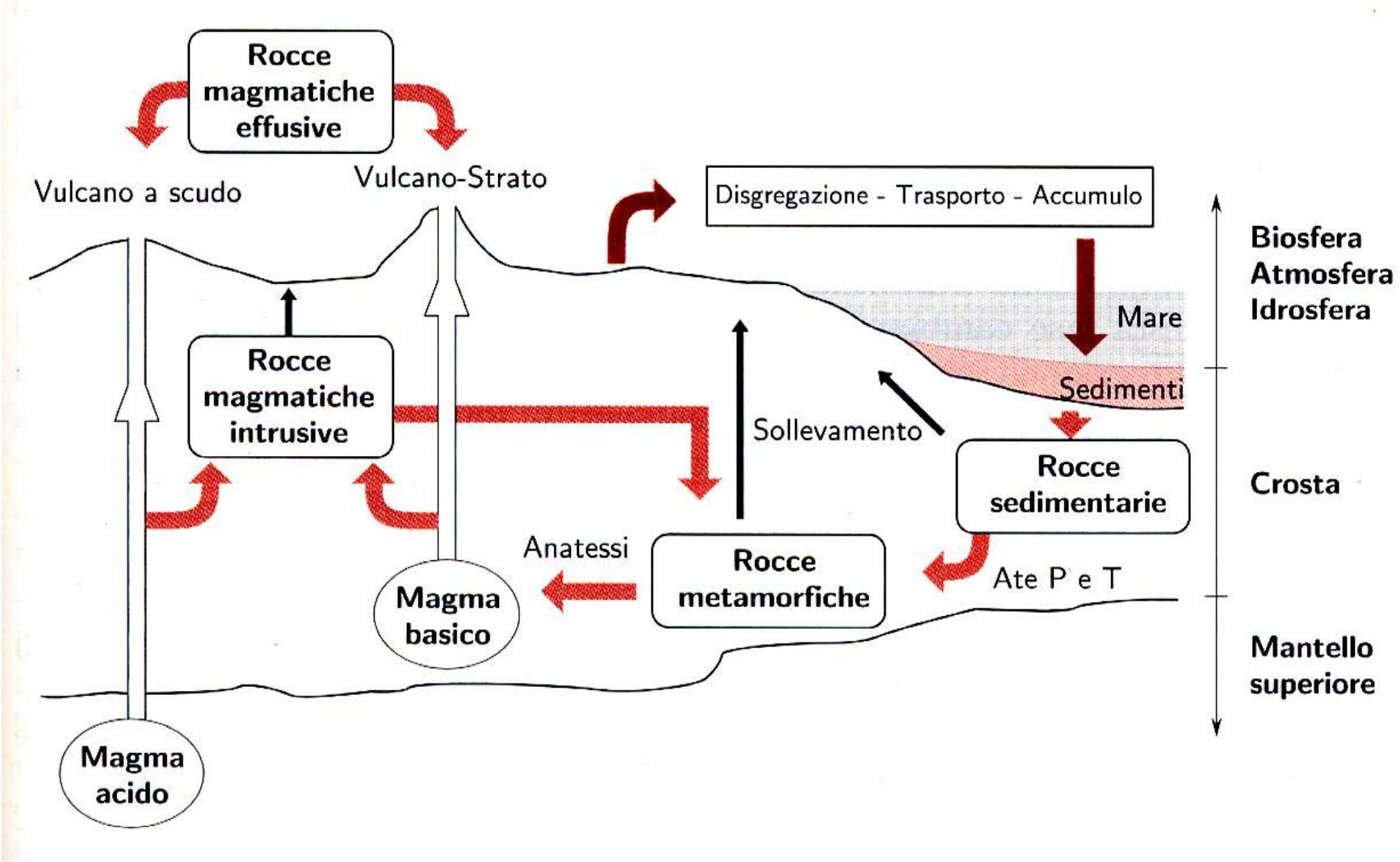
  Cenni di litogenetica

  Principali tipi di rocce

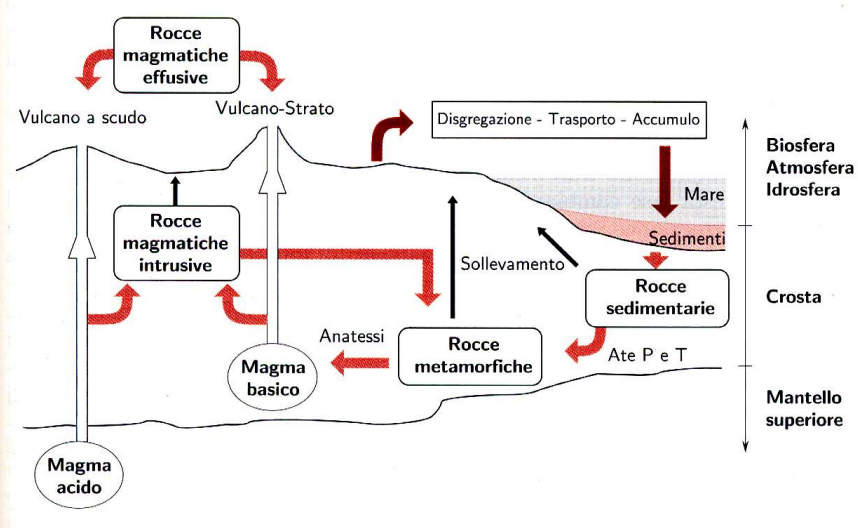
  Materiali per la litica

  Tecniche di lavorazione e proprietà

Cenni di litogenetica



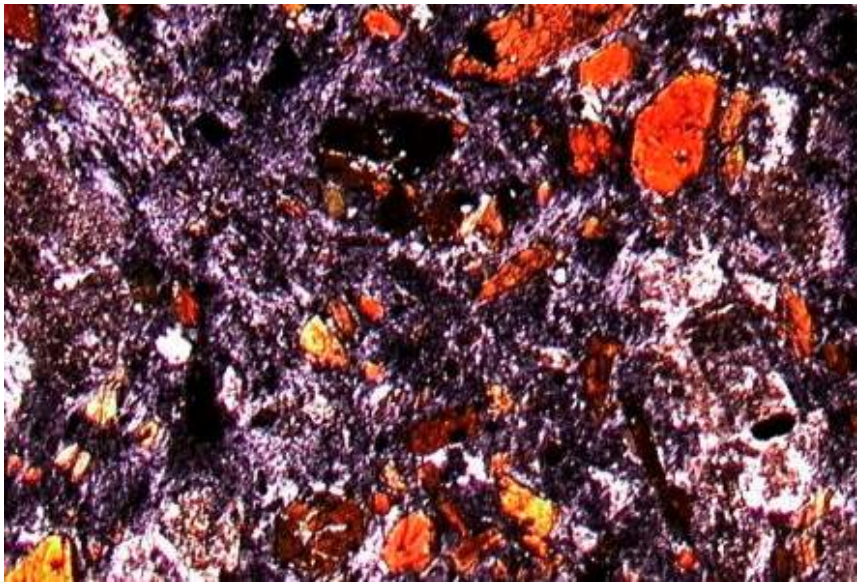
Cenni di litogenetica



Rocce Magmatiche Effusive

in genere microstalline e/o amorfe

- *Rocce Acide o Persiliciche (SiO_2>65%)*
- *Rocce Neutre o Mesosiliciche (65%>SiO_2>52%))*
- *Rocce Basiche o Femiche (52%>SiO_2>42%))*



Rocce Magmatiche Intrusive:

in genere macrocristalline

Litici e Lapidei

ACIDE

	MINERALI SIALICI			MINERALI FEMICI
	quarzo ortoclasio miche	plagioclasi Na ---------- Ca		olivina pirosseni anfiboli
Tessitura afanitica (effusive)	*riolite*	*andesite*	*basalto*	*olivin-basalto*
Tessitura faneritica (intrusive)	*granito*	*diorite*	*gabbro*	*peridotite*

BASICHE

Cenni di litogenetica

Rocce Sedimentarie - la genesi

- *Alterazione*

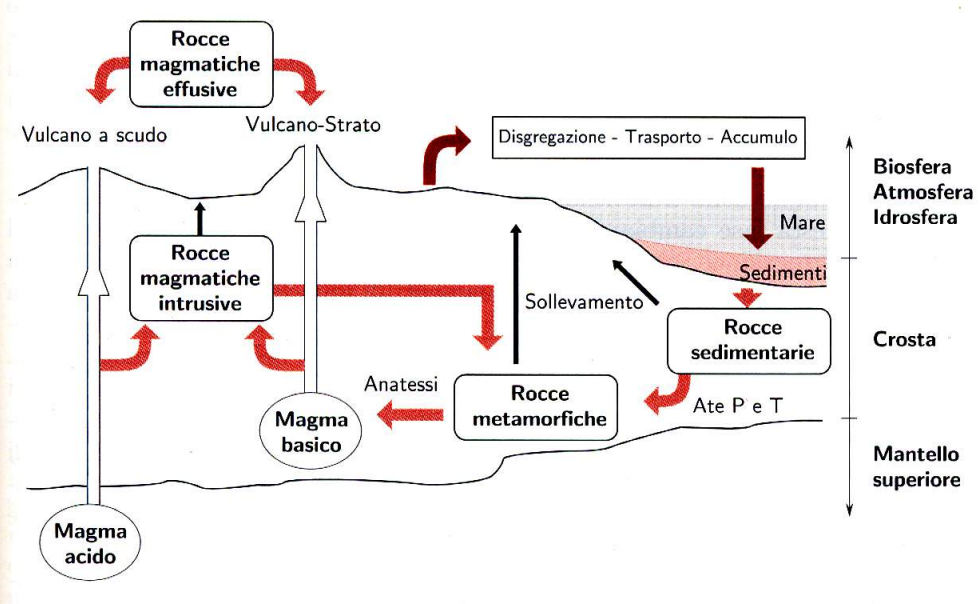
Fisica (disgregazione per azione di aria ed acqua)

Chimica (reazioni acido base, permeazione con acqua, complessazione, etc)

Biologica (calpestio,interazioni con vegetali, organismi litofagi, etc)

- *Trasporto*

Cambio di forma e dimensioni dei clasti



-*Sedimentazione*

Accumulo dei frammenti in base a dimensioni e velocità di trasporto

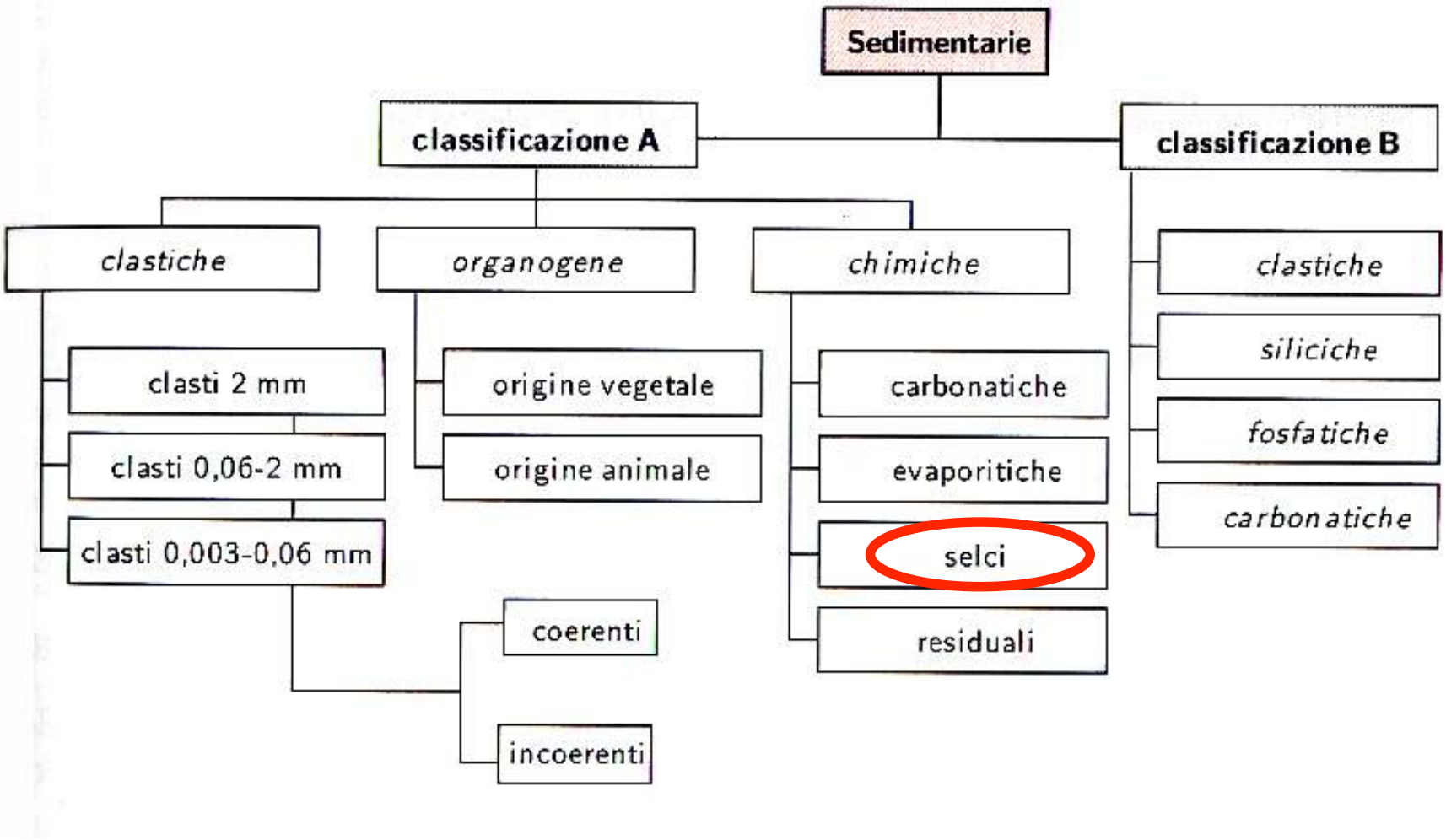
- *Diagenesi*

Serie di trasformazioni chimico-fisiche che portano alla litificazione….

Clasti – Matrice - Cemento

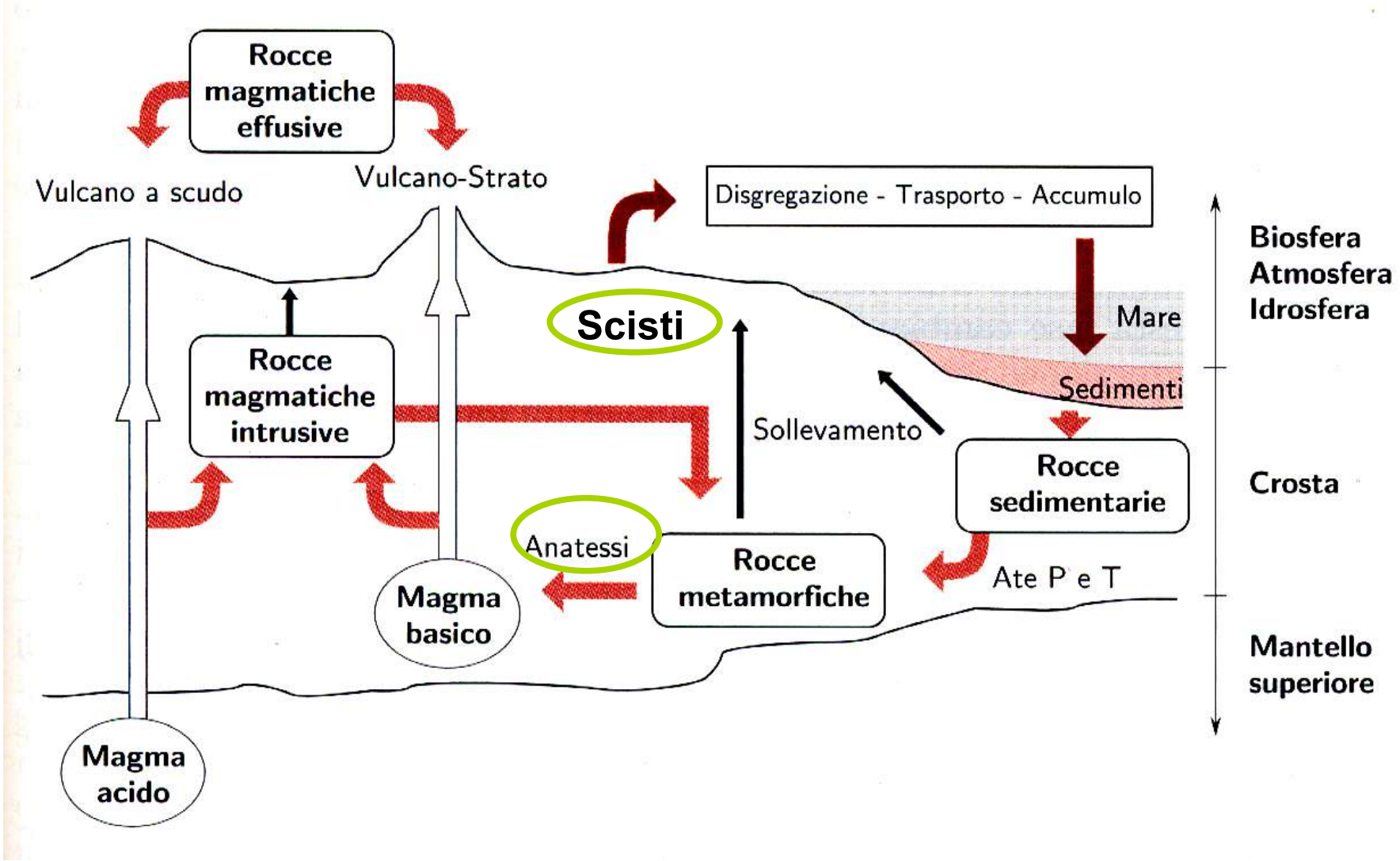
Litici e Lapidei

Rocce Sedimentarie - Classificazione



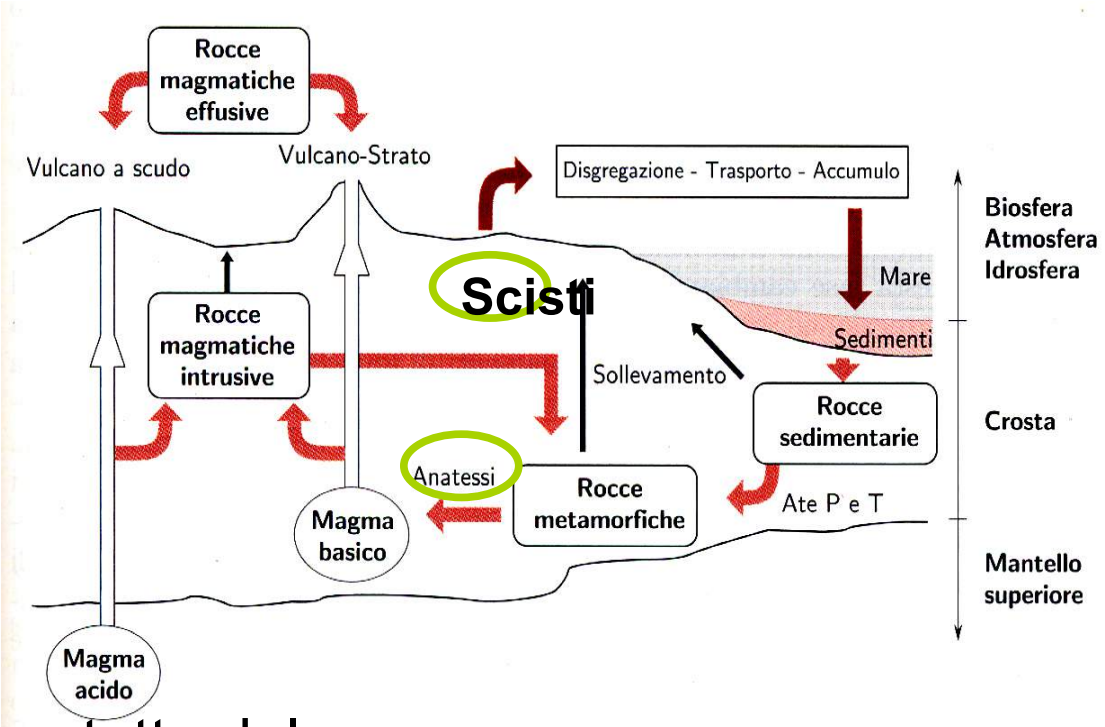
Cenni di litogenetica

Rocce Metamorfiche



Cenni di litogenetica

Rocce Metamorfiche



Anatessi: da fusione per contatto del protolita.

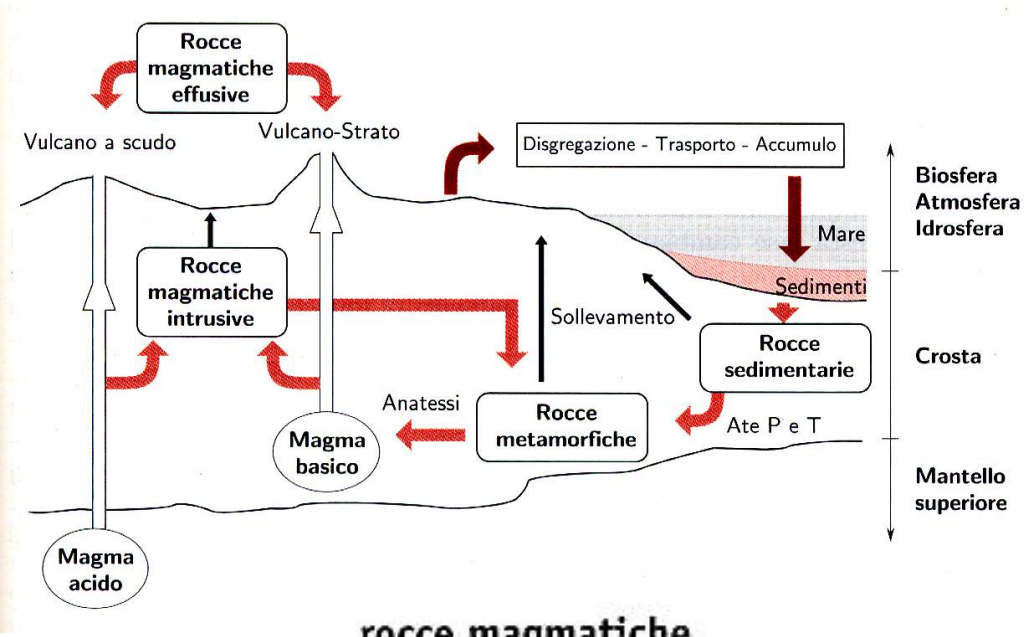
Scisti: da rammollimento o solo parziale fusione del protolita

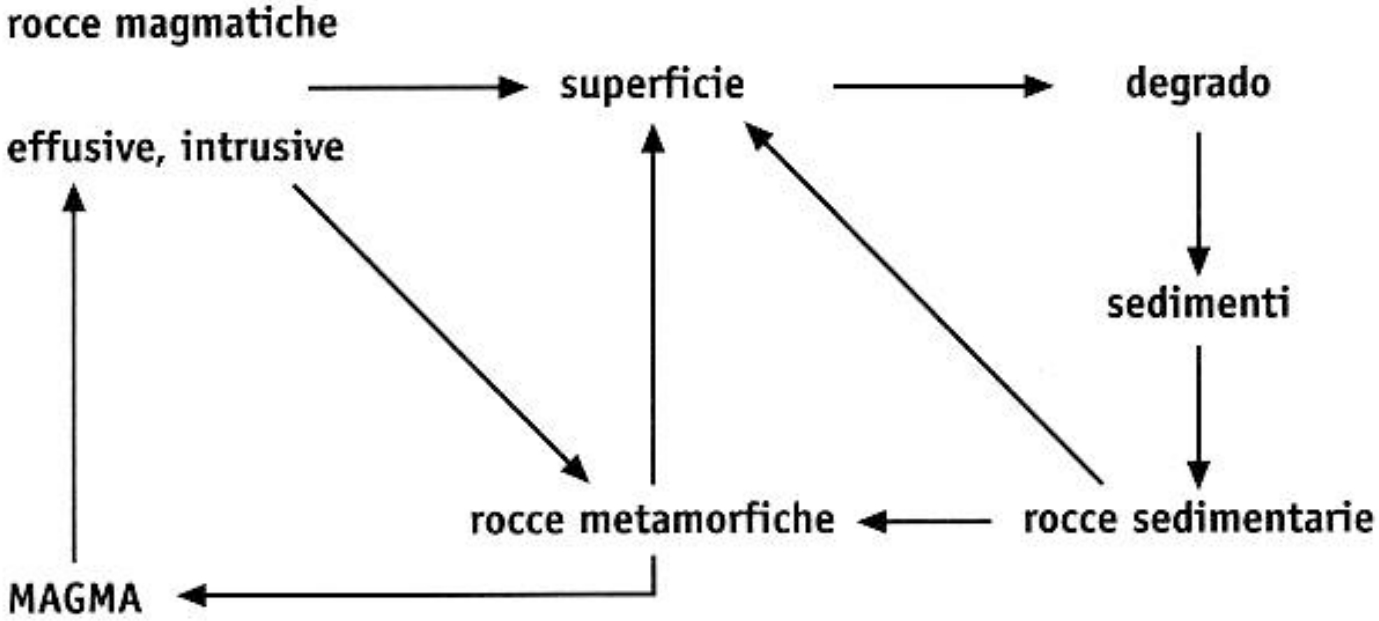
Orto- protolita igneo;

Para- protolita sedimentario;

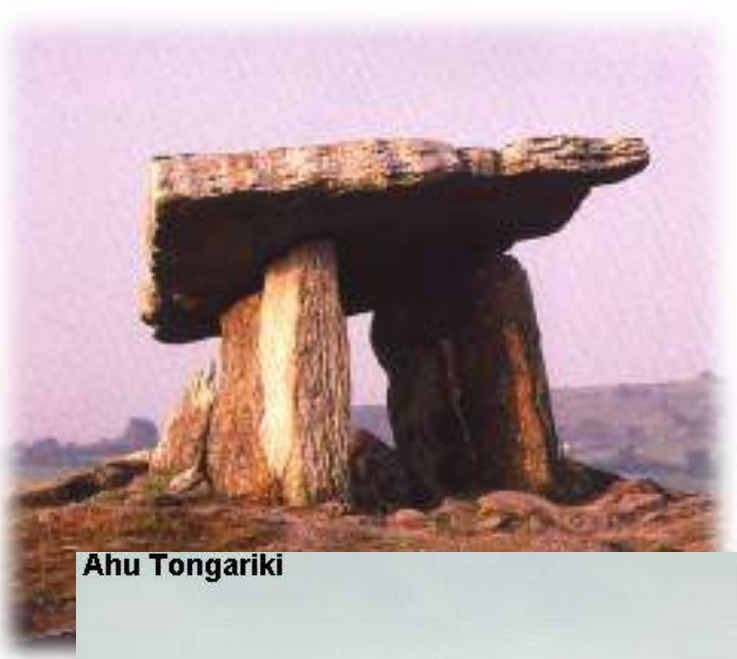
Meta- stessa tessitura del protolita

Cenni di litogenetica





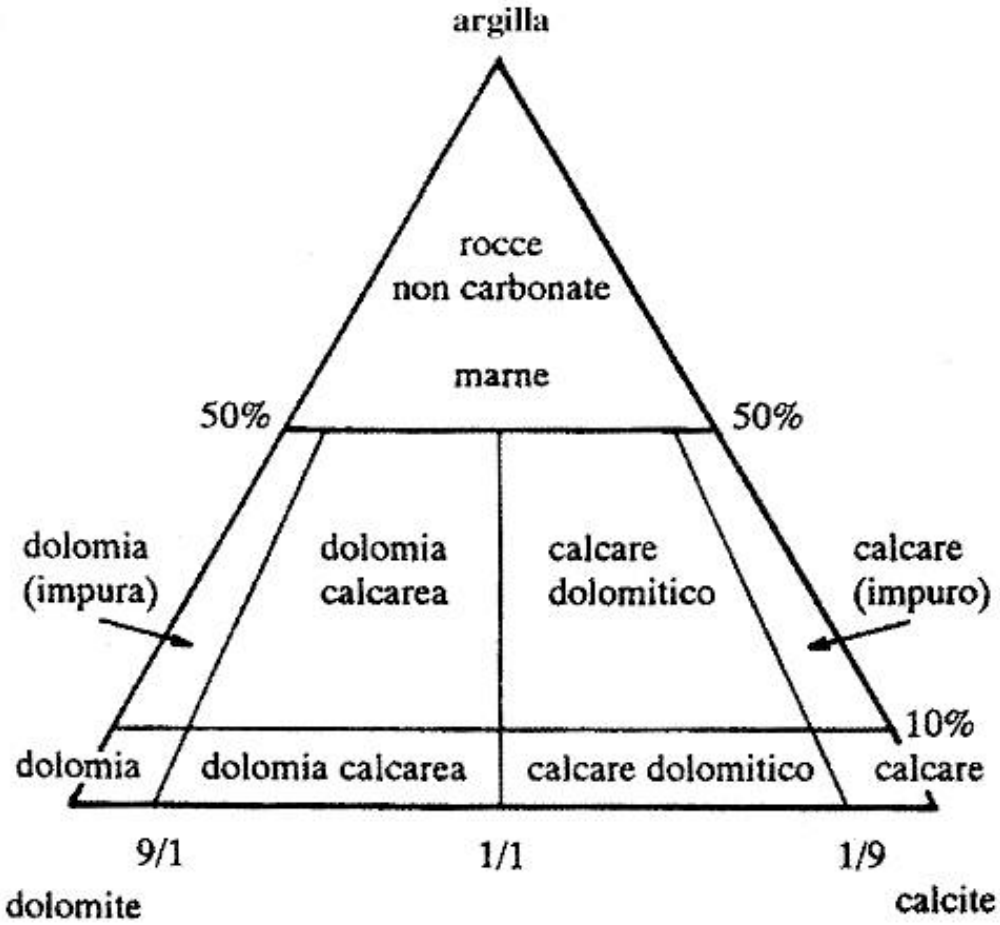
Tipi di rocce



Litici e Lapidei

Calcari

Rocce sedimentarie carbonatiche: $CaCO_3$ e $CaMg(CO_3)_2$



Calcari

Rocce sedimentarie carbonatiche: $CaCO_3$ e $CaMg(CO_3)_2$

Origine

- **Organica:** accumulo di spoglie di organismi vegetali e/o animali, generalmente in bacini lacustri o marini. Presenza di resti fossili.

- **Chimica:** precipitazione chimica da acque calcaree (C. evaporitici, c. oolitici, c. pisolitici, tufo calcareo).

- **Clastica:** frammenti prodotti da frantumazione di rocce preesistenti.

Marmi: Calcari metamorfici

Microstruttura:

Cristalli micrometrici o submicrometrici formati per precipitazione termica

Matrice sostanzialmente inesistente: no deposito o cemento intergranulare

Rocce ignee (magmatiche) a elevato contenuto di SiO_2

Microstruttura:

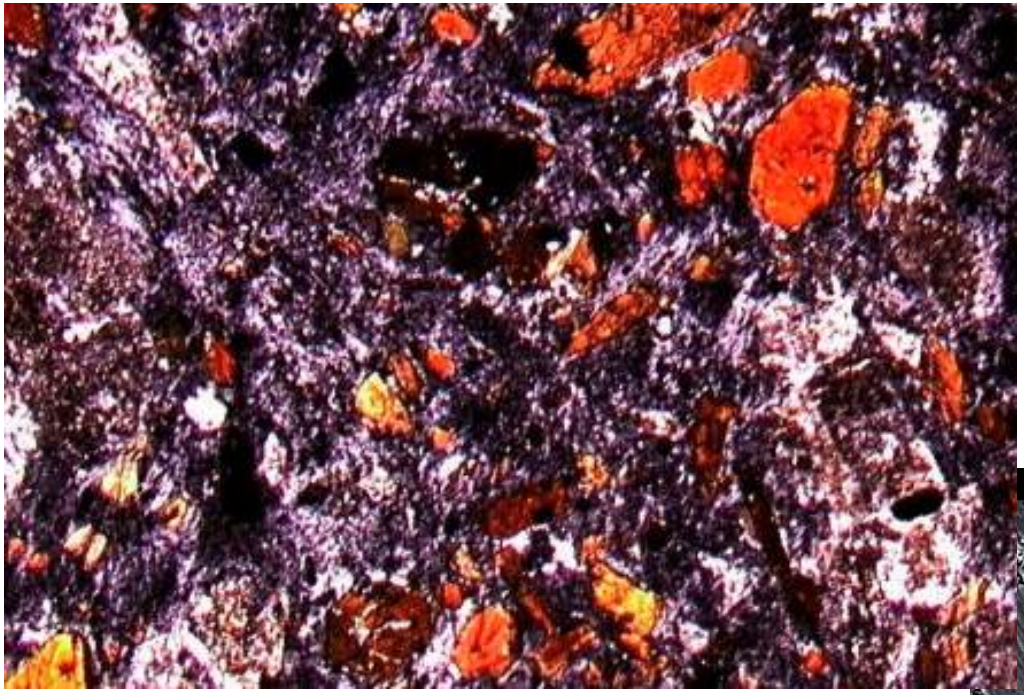
Cristalli micrometrici in

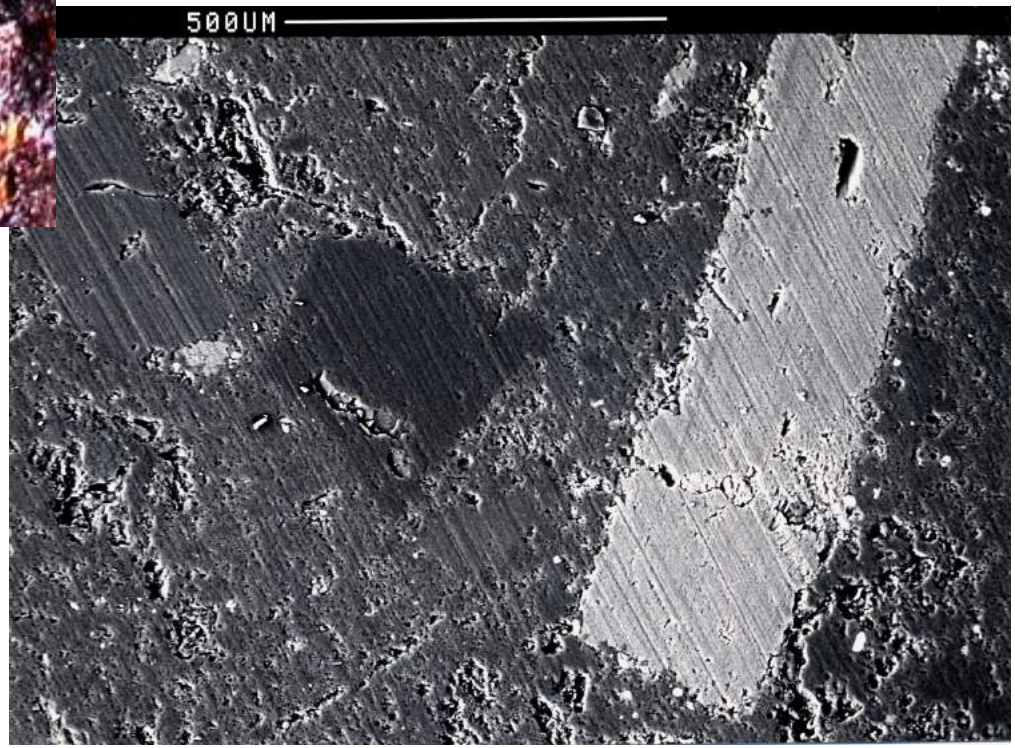
Matrice amorfa o criptocristallina.

Graniti

Tipi di rocce

Rocce porfiriche (ignee effusive)





Rocce sedimentarie detritiche: le Arenarie

-***Microstruttura:*** *Clasti e cemento. Elevata porosità.*

- ***Clasti:*** *quarzo, feldspati, mica, ematiti, etc.*

- ***Cemento*** *che qualifica le arenarie in:*

Carbonatiche

Silicee

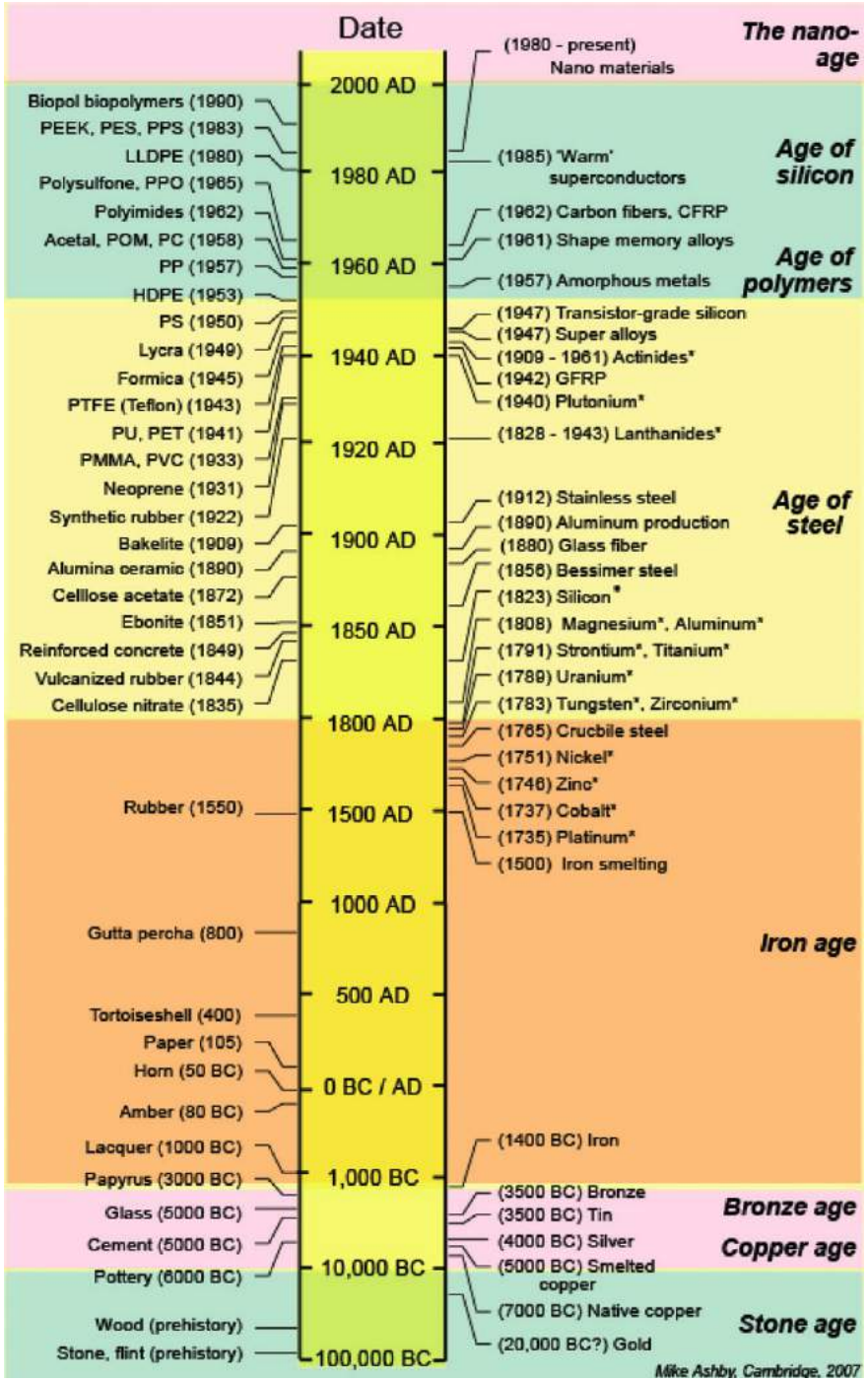
Ferruginose

Argillose

Tufo: *roccia sedimentaria piroclastica*

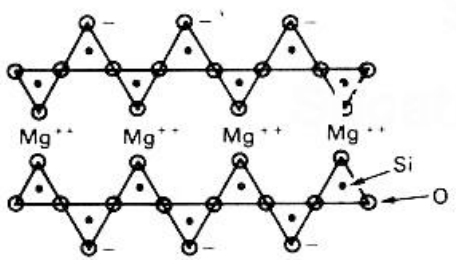
Tipi di rocce

- Disponibilità
- Resistenza meccanica
- Lavorabilità
- Varietà cromatica

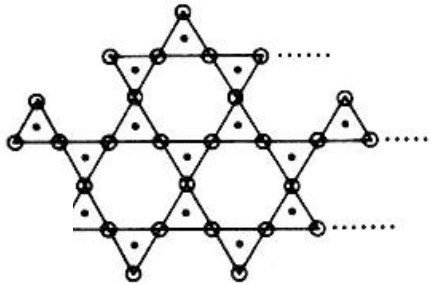


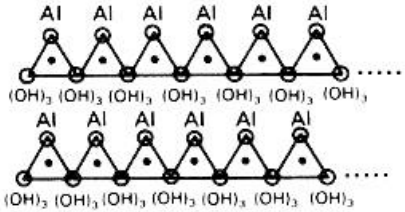
Litici e Lapidei

Materiali litici a base silice

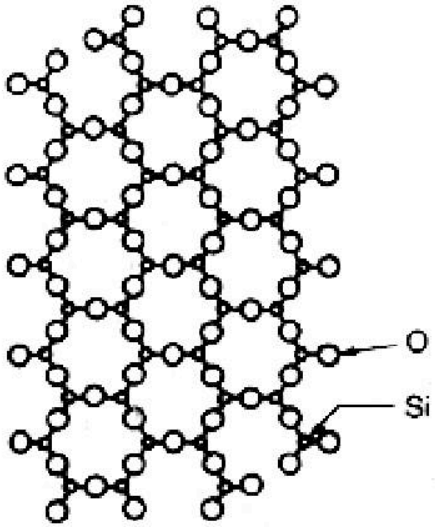


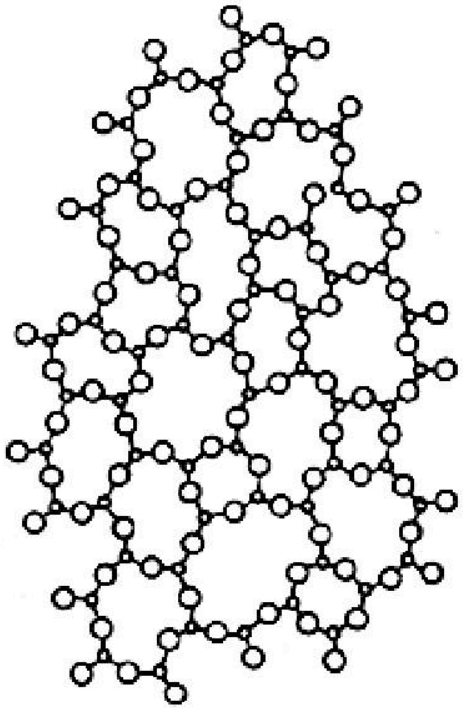
Struttura silicatica lineare
(Enstatite, $MgSiO_3$)





Planare (argille)





Quarzo e vetro di silice

Glossario e classificazione

- Silice macrocristallina

Quarzo
(Quartz)

Silcrite *(Silcrete)*

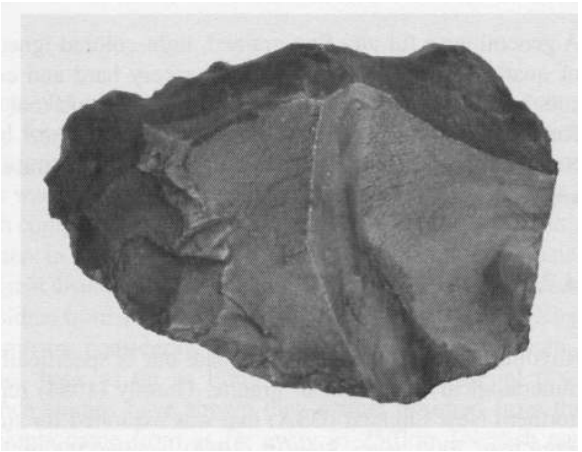
Conglomerato (sedimentario) di sabbia cementante e ghiaia fine, tipica di ambienti aridi

Quarzite *(Quartzite)*

Ortoquarzite *(arenaria): Sabbia silicea cementata da silice praticamente pura.*

Metaquarzite:

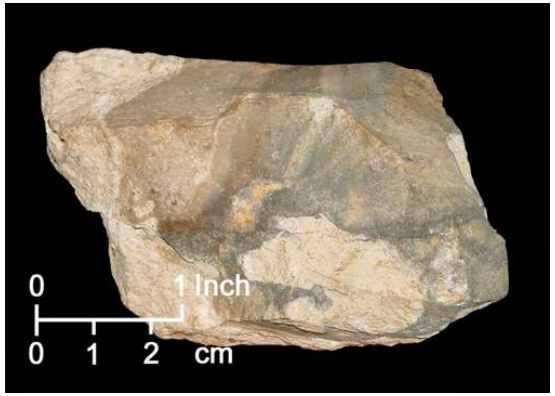
Arenaria metamorfizzata con accrescimento dei grani di quarzo presenti al suo interno.



Litica - Silice microcristallina

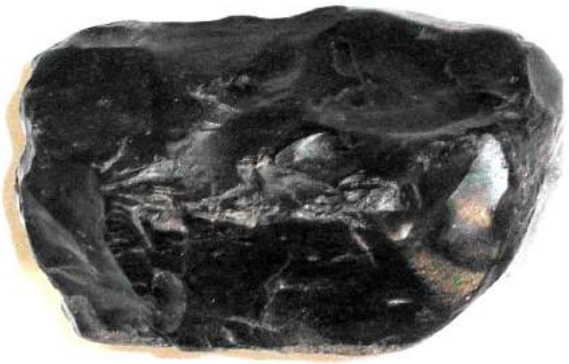
Calcedonio

(Chalcedony)



Selce

(chert - flint)



Anfiboliti

Scisti verdi

Scisti anfiboliti

Giadeiti

Eclogiti

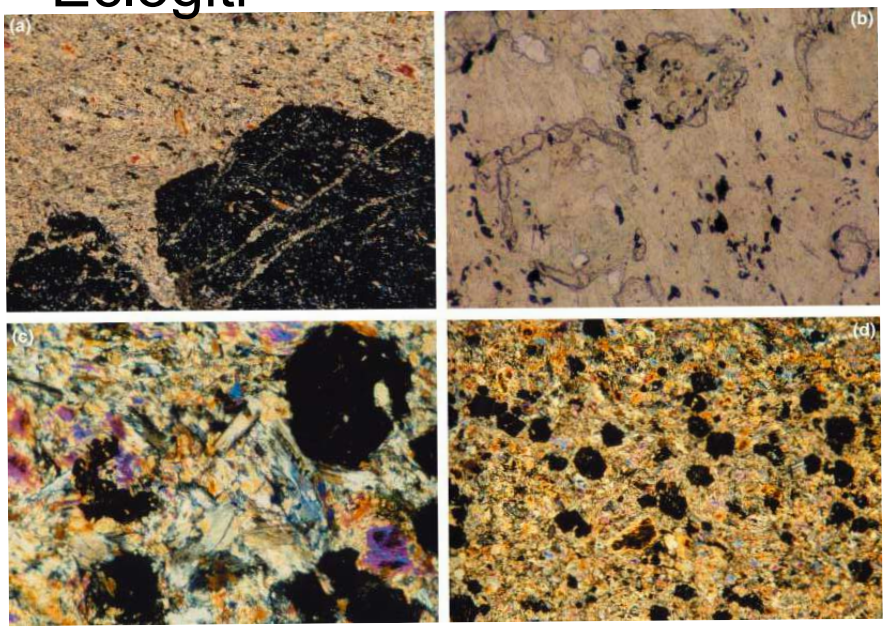
La pietra verde

Rocce e minerali ignei basici metamorfizzati

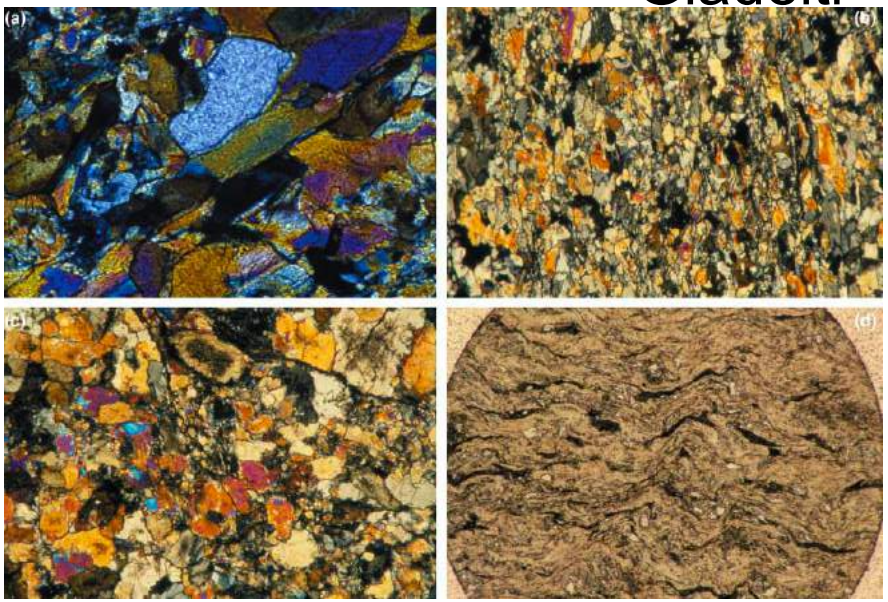
Litica

Lithological groups	*All samples (n = 999)*		*Axe blades (n = 651)*		*Chisels (n = 29)*		*Rings/ ornaments (n = 40)*		*Others* (n = 279)*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
HP metaophiolites	*829*	*83.0*	*586*	*90.0*	*26*	*89.7*	*13*	*32.5*	*204*	*73.1*
Eclogites	405	40.5	318	48.8	13	44.8			74	26.5
Jades	233	23.3	177	27.2	7	24.1	2	5.0	47	16.8
Omphacite (jadeite) schists	40	4.0	28	4.3	1	3.5			11	3.9
Glaucophane rocks	26	2.6	15	2.3	4	13.8			7	2.5
Greenschists	23	2.3	18	2.8	1	3.5			4	1.4
Serpentinites	102	10.2	30	4.6	–	–	11	27.5	61	21.9
Other lithologies†	*170*	*17.0*	*65*	*10.0*	*3*	*10.3*	*27*	*67.5*	*75*	*26.9*

Eclogiti



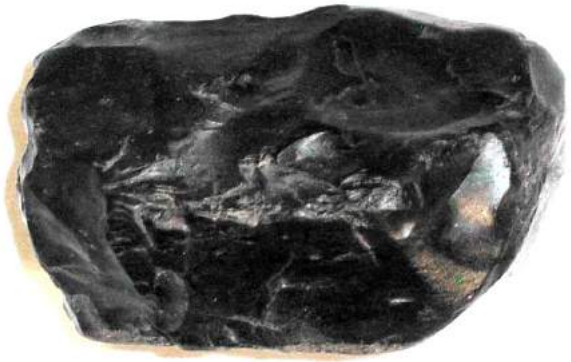
Giadeiti



D'Amico C., Neolithic "Greenstone" axe blased from northwestern Italy across Europe: a first petrographic comparison, Archaeometry, 47, 235-252 (2005)

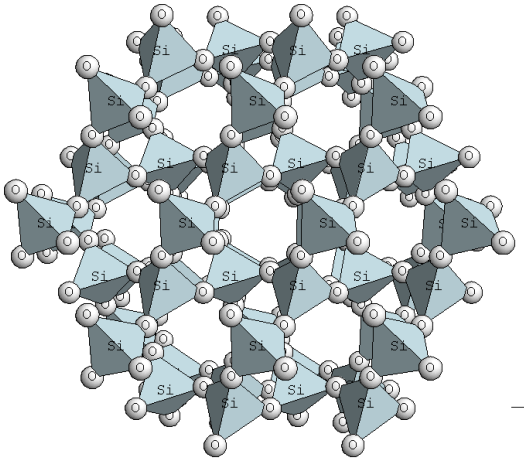
Litici e Lapidei

Litica



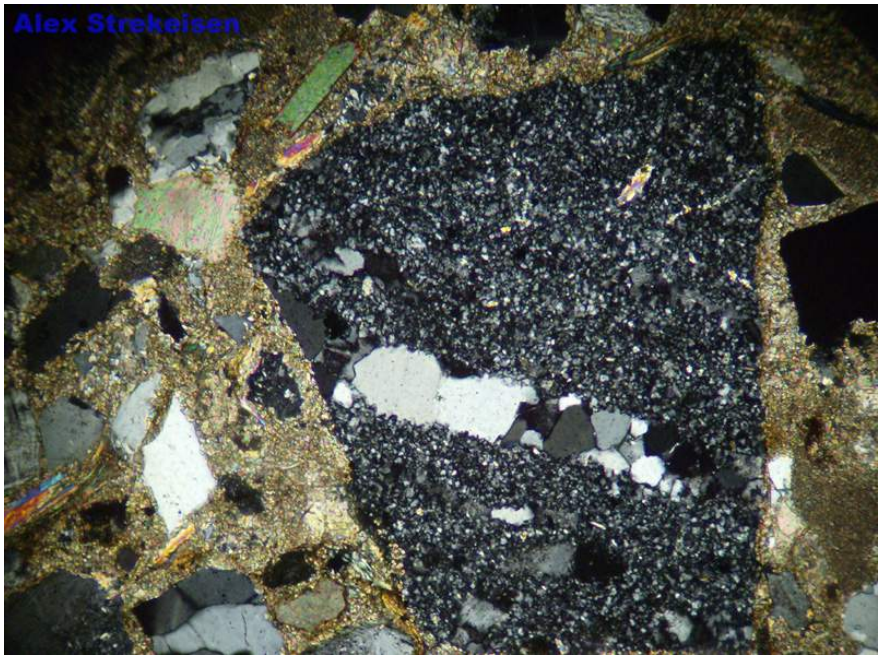
Selce

SiO_2



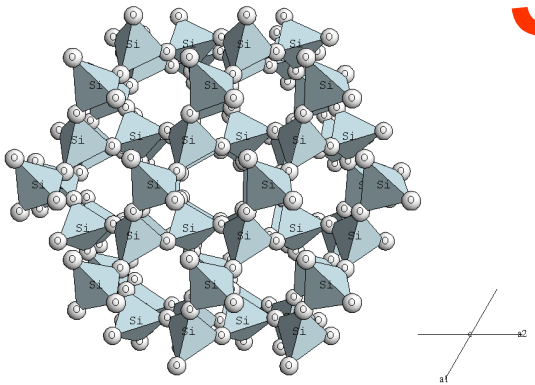
Quarzo

Litica



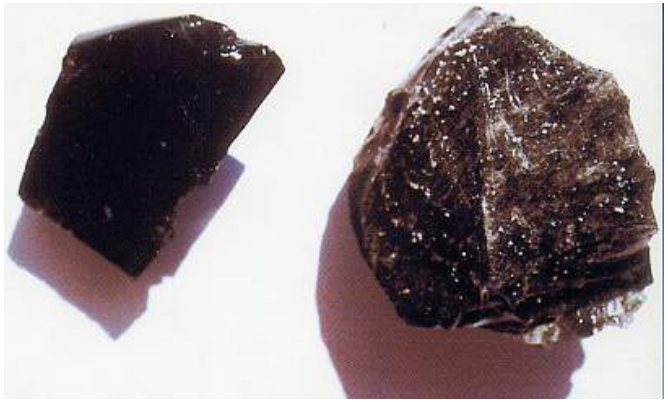
Selce

SiO_2

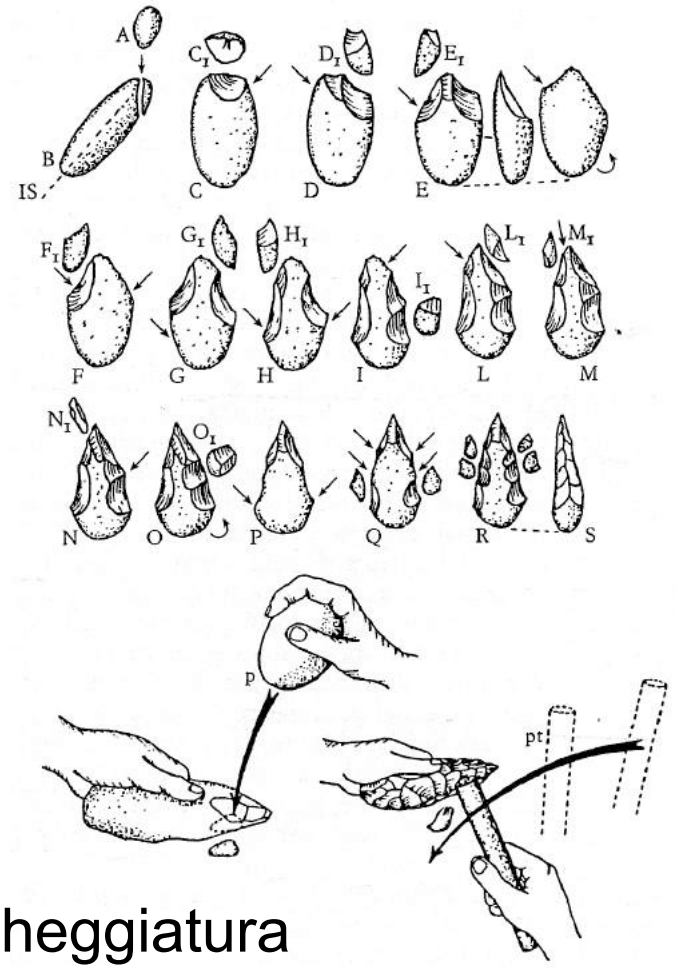


Quarzo

Litica - Tecnica



Ossidiana



- Scheggiatura
- Martellatura e levigatura
- Taglio
- Tornitura

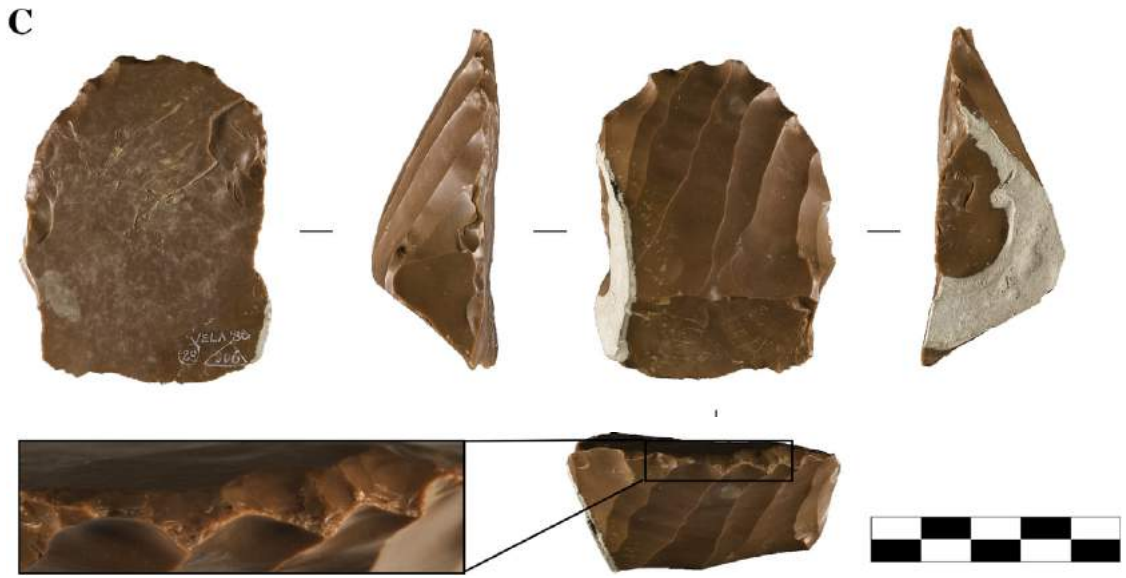
Perché la selce scaldata si scheggia “meglio”?

- Rimozione di frammenti più lunghi durante la scheggiatura;
- Lavorazione completa in un numero inferiori di passi;
- Tagliente delle lame più affilato.

F.Santaniello, S. Grimaldi, A. Pedrotti, S. Gialanella,,Quaternary International (2015)

Caratteristiche identificative di selci scaldate (*heated flint*):

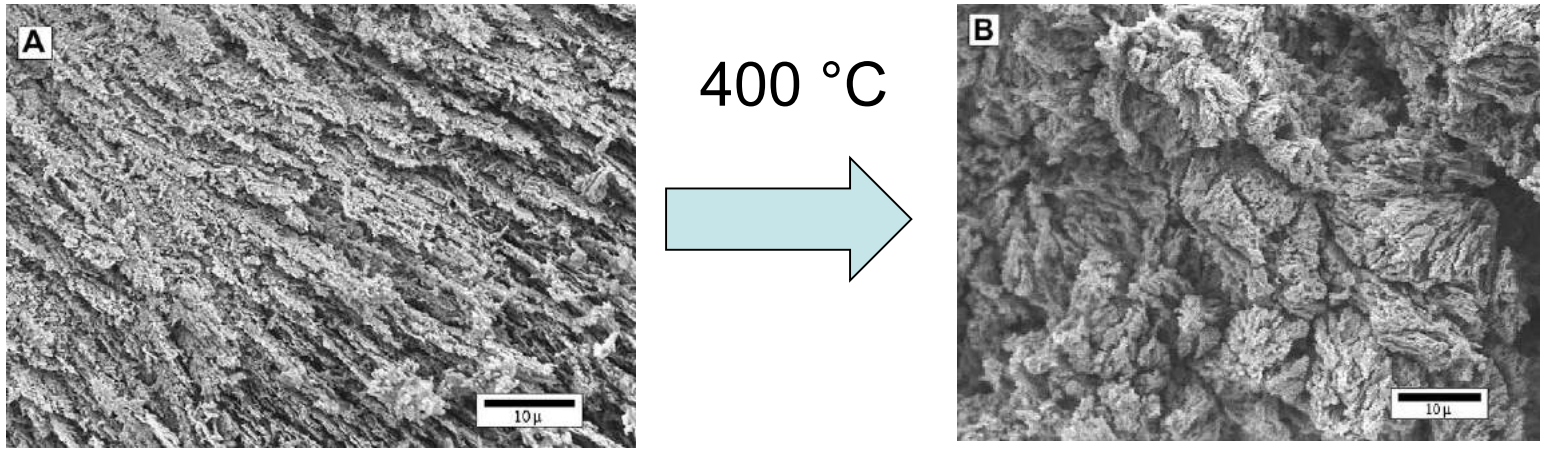
- Colorazione scura;
- Lucentezza e aspetto “greasy” ;
- Danneggiamenti evidenti, come microfratturazione e opacizzazione superficiale (-> selce bruciata (*burnt flint*)).



F.Santaniello, S. Grimaldi, A. Pedrotti, S. Gialanella,,Quaternary International (2015)

Alcuni aspetti "caratteristici" proposti quali identificativi delle selci scaldate:

1- Ricristallizzazione della matrice, migliore adesione dei grani cristallini e riduzione delle loro dimensioni medie.



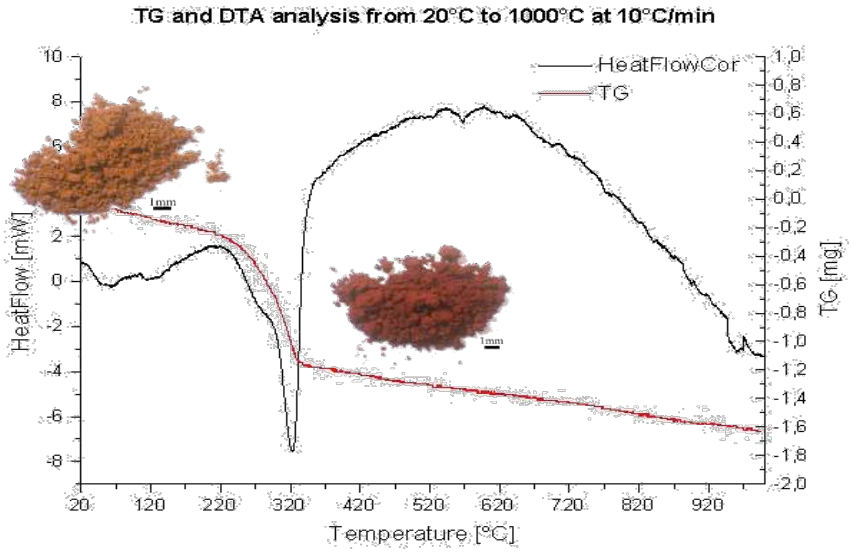
2- Microfratturazione da inclusioni di acqua lungo i bordi di grano.

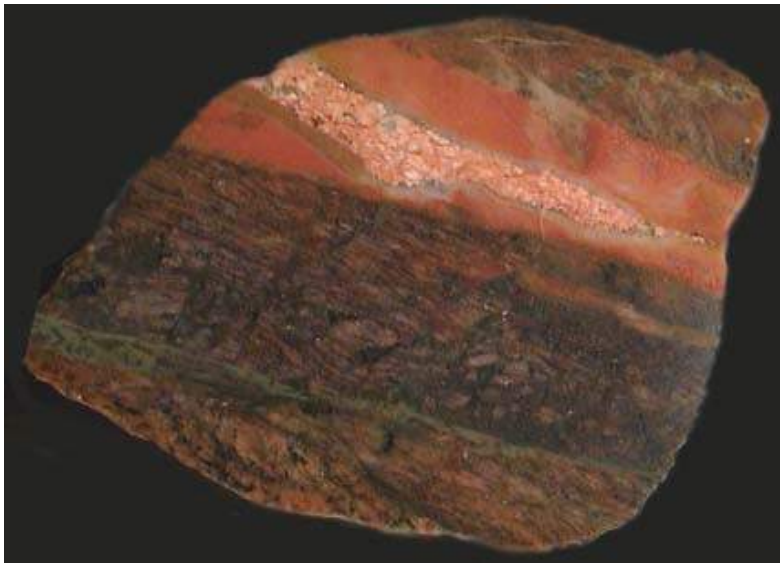
3- Microfratturazioni e microdeformazioni interne alla selce.

Caratteristiche microstrutturali delle selci scaldate:

4- Trasformazione goethite-ematite.

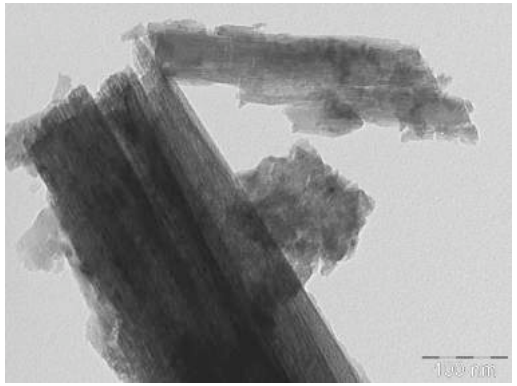
$$2FeO(OH) \Rightarrow Fe_2O_3 + H_2O$$





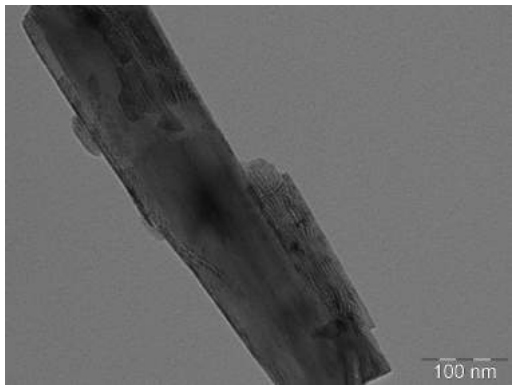
Diaspro (jasper) o calcedonio rosso

Caratteristiche microstrutturali delle selci scaldate:



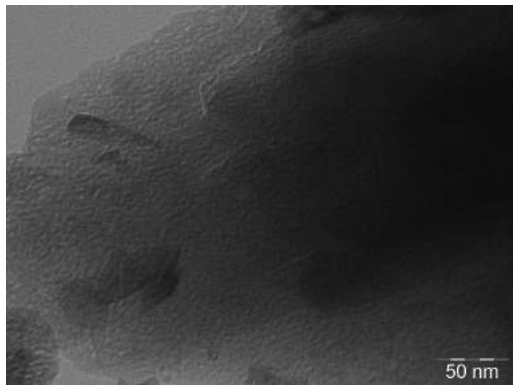
25 °C

Goethite.



300 °C

Ematite.



400 °C

Ematite.

Tecnica - proprietà

L'approccio "Domanski"

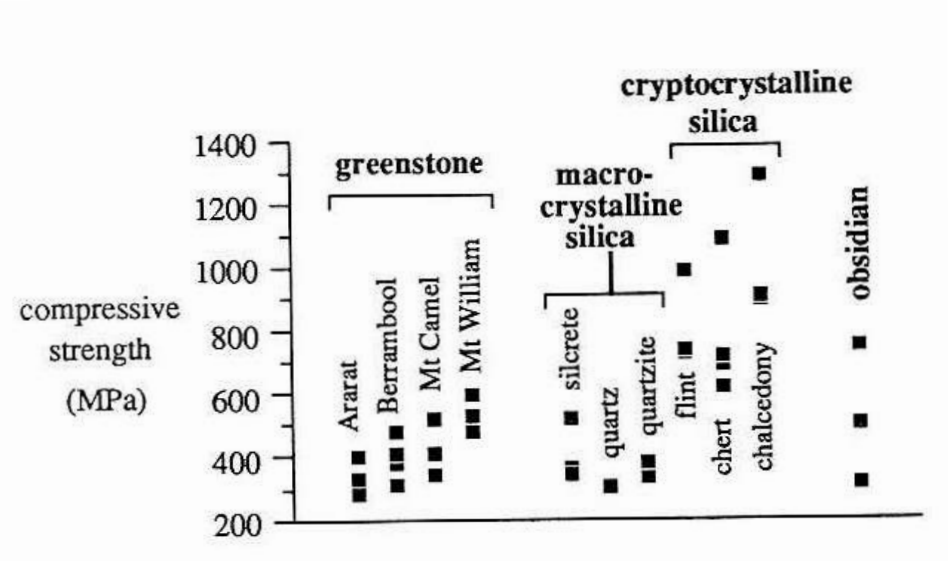
Domanski, M., Webb, J.A., 1992. Effect of heat treatment on siliceous rocks used in prehistoric lithic technology. Journal of Archaeological Science 19, 601-614.

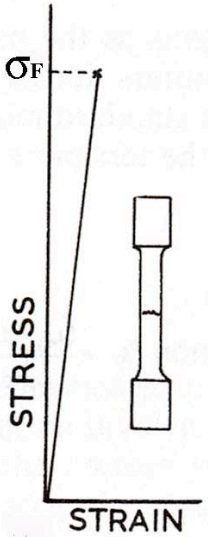
Domanski, M., Webb, J.A., Boland, J., 1994. Mechanical properties of stone artefact materials and the effect of heat treatment. Archaeometry 36, 177-208.

Domanski, M., Webb, J., Glaisher, R., Gurba, J., Libera, J., Zakoscielna, A., 2009. Heat treatment of Polish flints. Journal of Archaeological Science 36, 1400-1408.

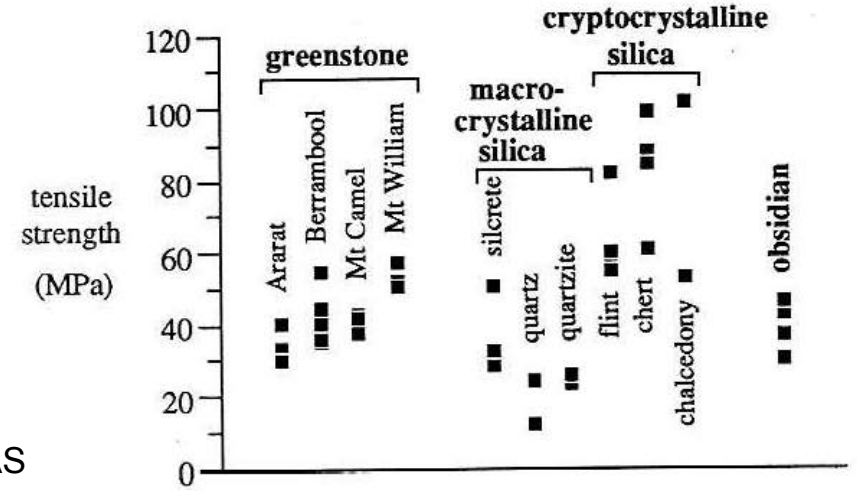
L'approccio "Domanski"

- Resistenza a compressione





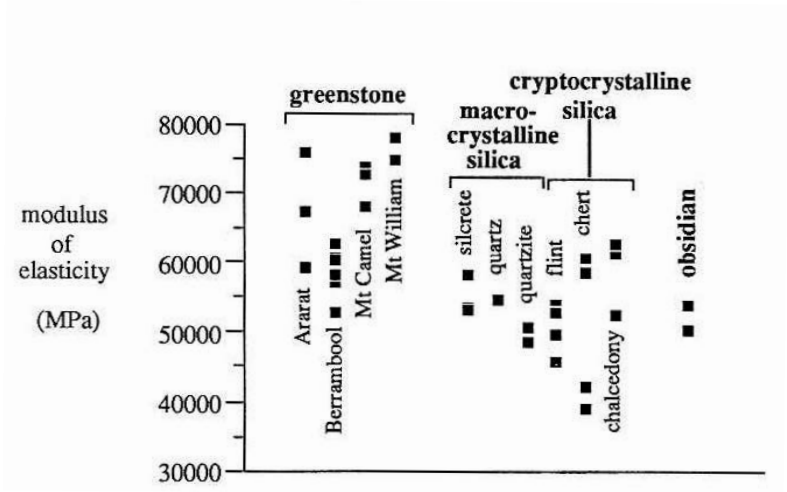
- Resistenza a trazione

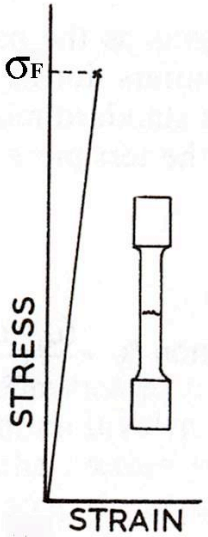


Domanski M, Webb JA, Effect of heat treatment…., JAS **19**, 601-614 1992

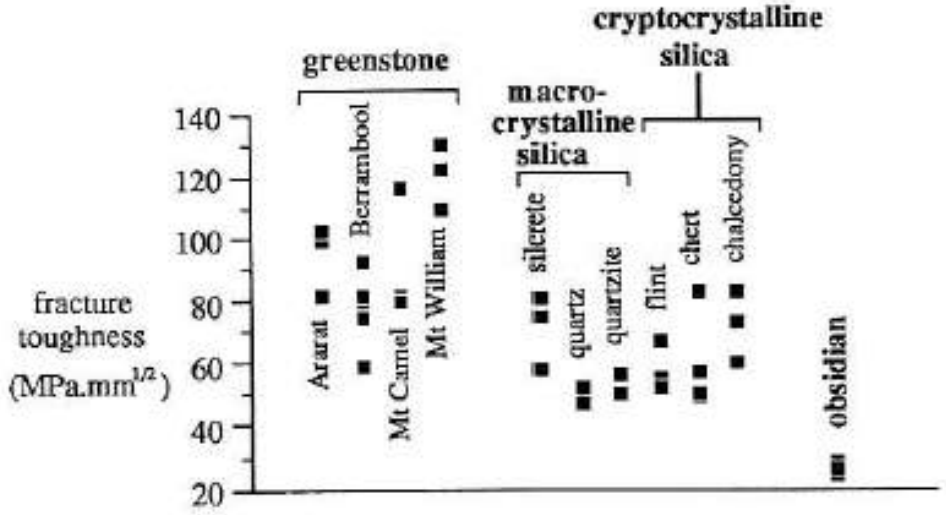
Tecnica - proprietà

- Modulo elastico



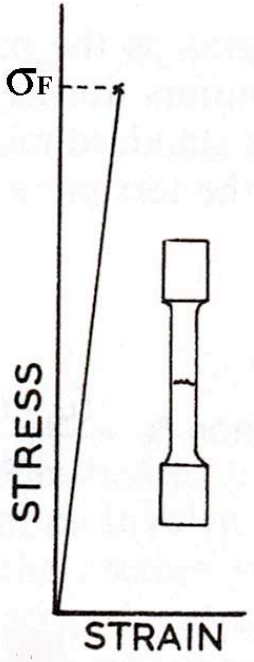


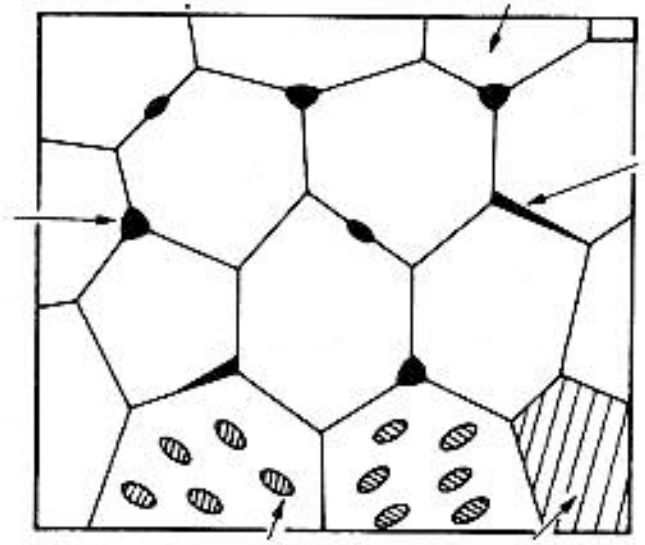
- Tenacità a frattura

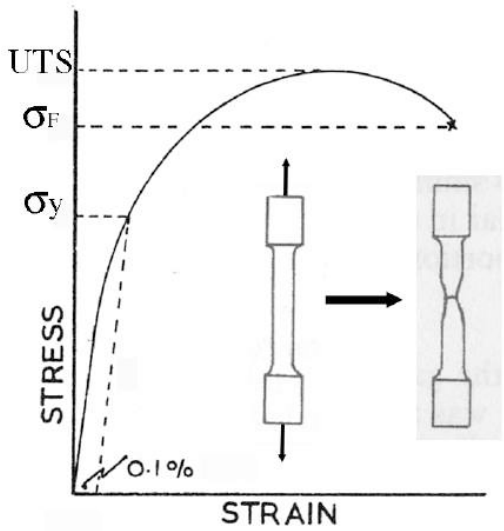


Tecnica - proprietà

- Tenacità a frattura: definizione

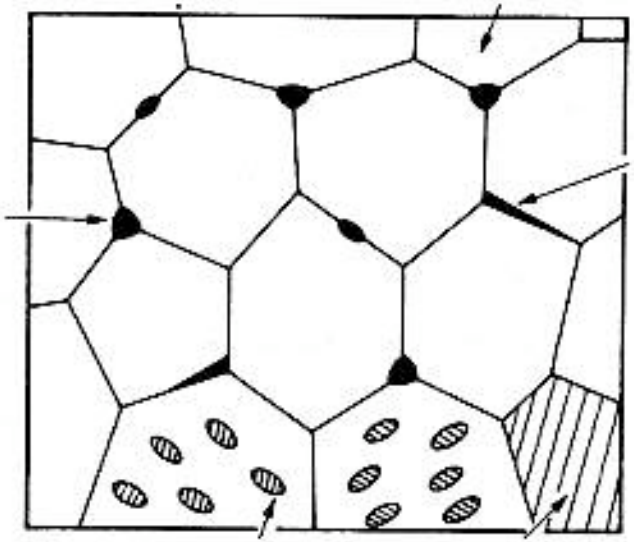


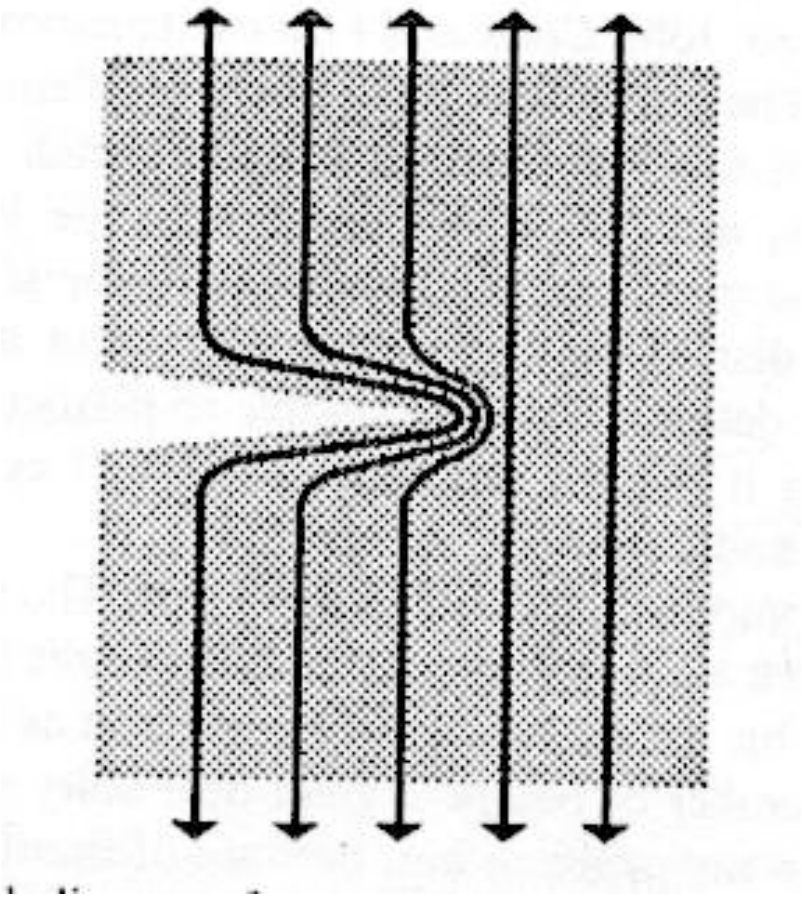




Tecnica - proprietà

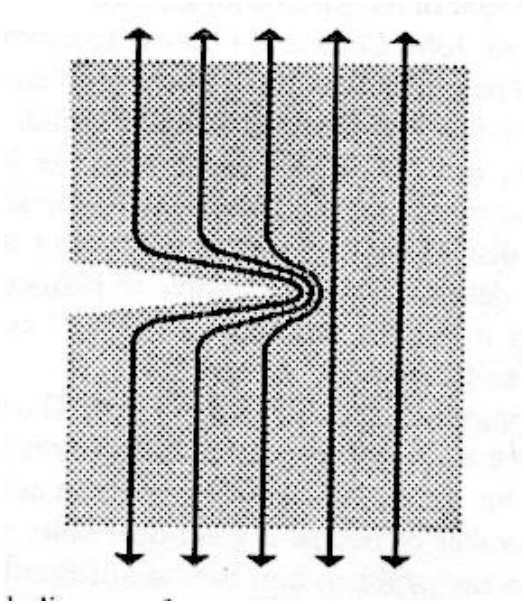
- Tenacità a frattura: definizione



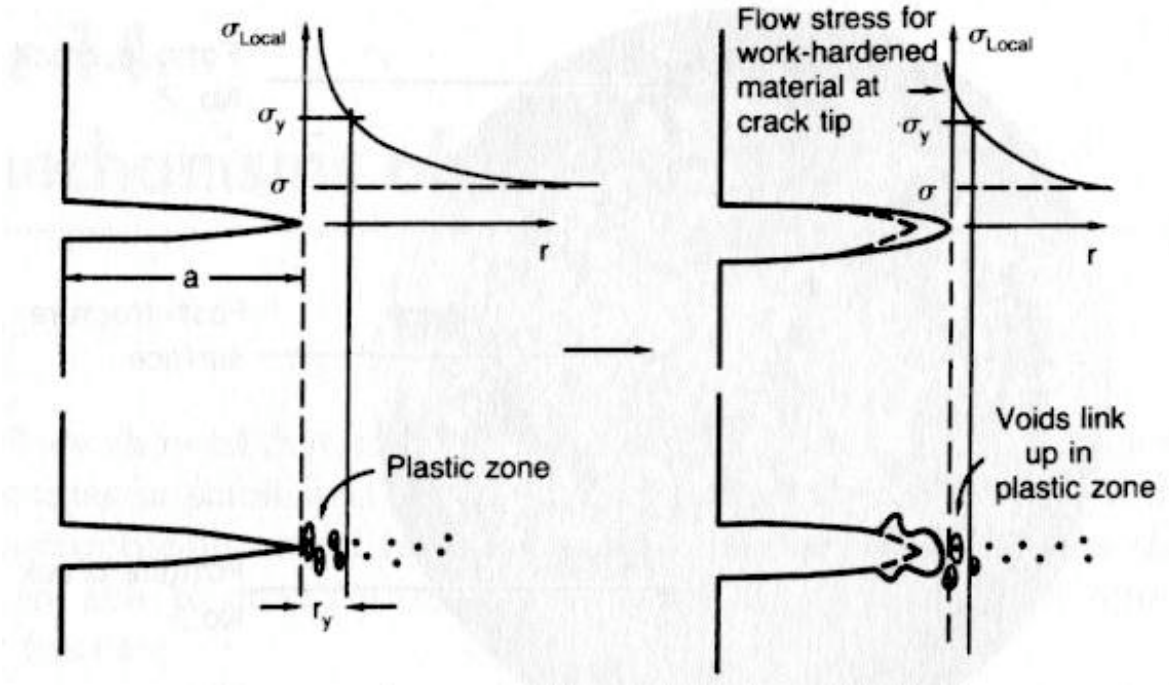


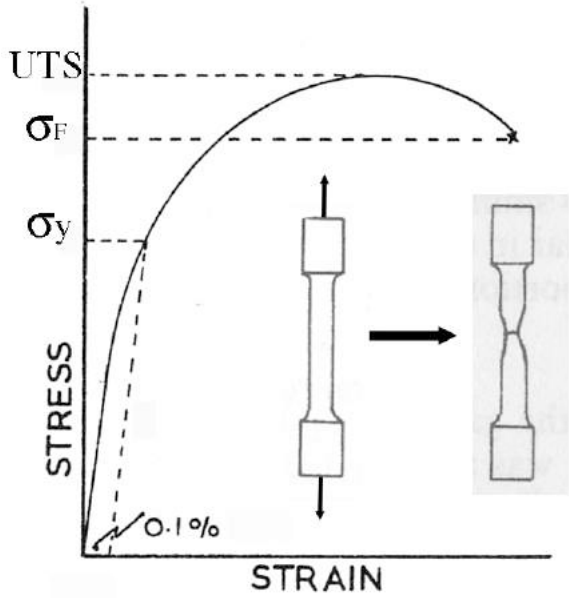
Tecnica - proprietà

- Tenacità a frattura: definizione

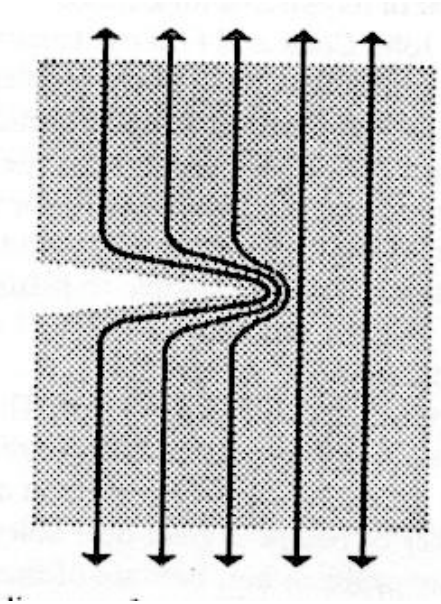


Materiale duttile

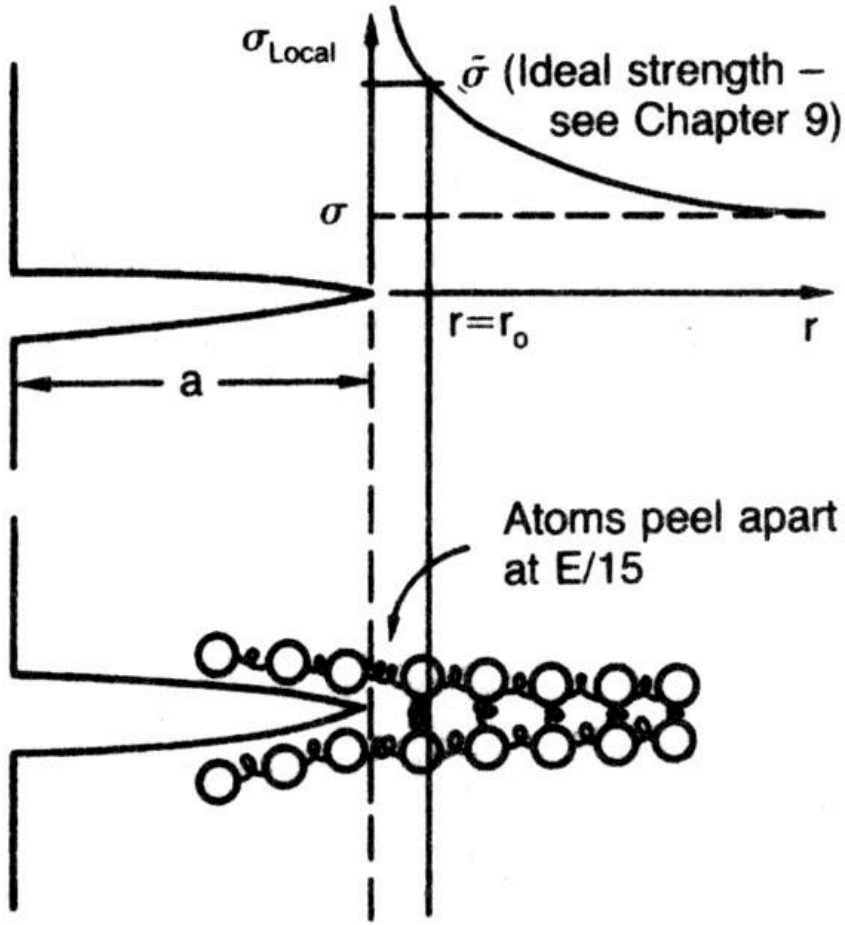


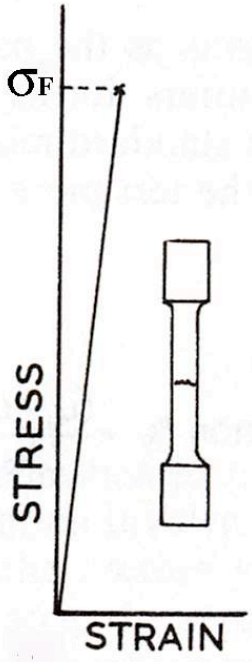


- Tenacità a frattura: definizione

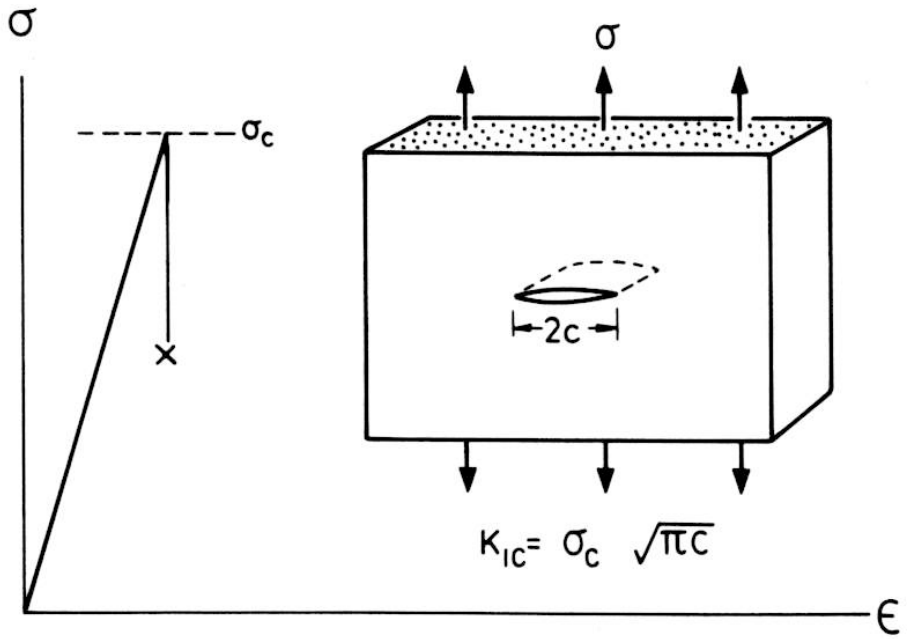


Materiale fragile





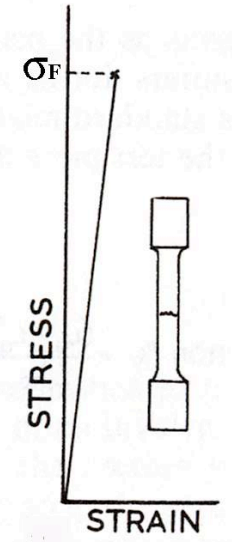
- Tenacità a frattura: definizione

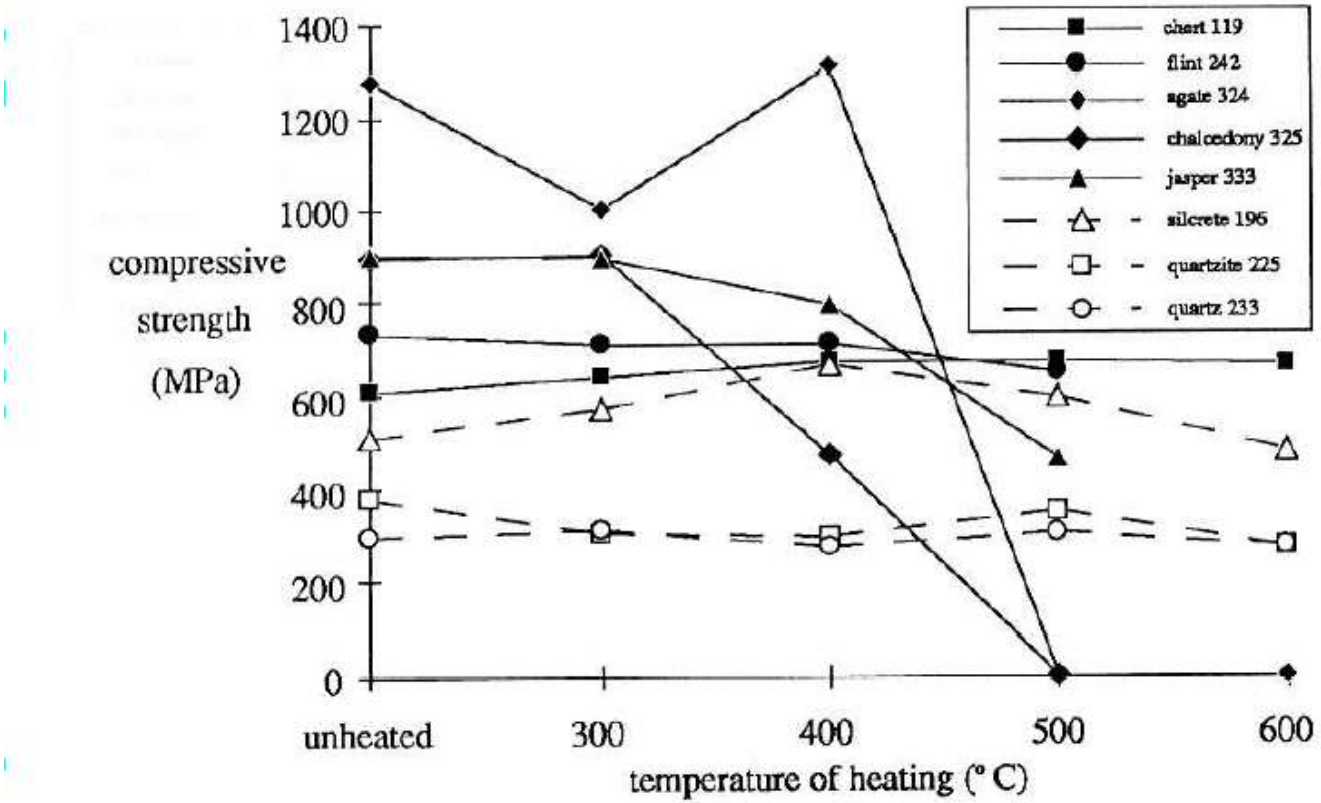


$$K_C = \sigma_C \times \sqrt{\pi c}$$

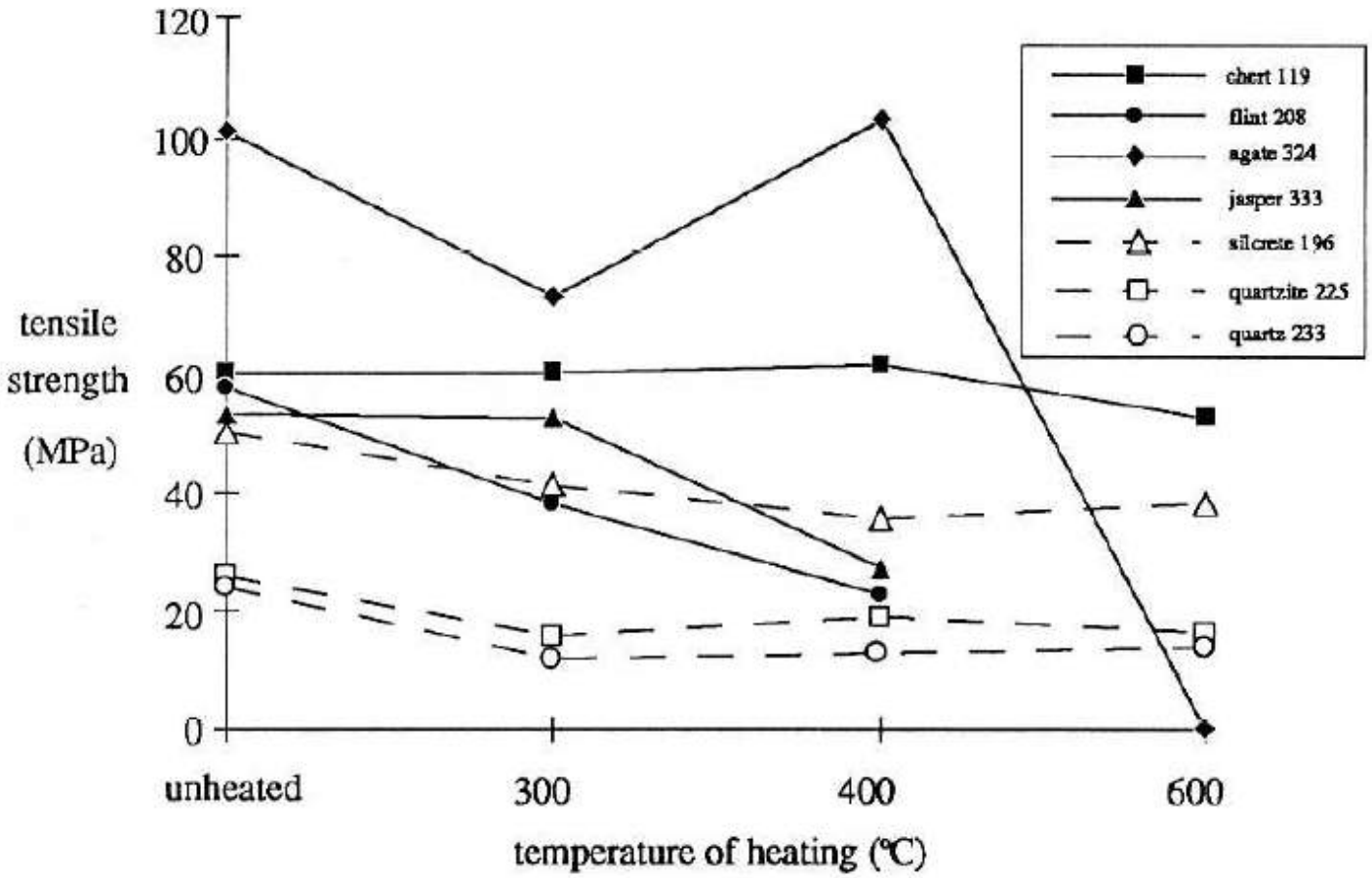
La tenacità a frattura, Kc, di un materiale ci dice quale è lo sforzo che questo è effettivamente in grado si sopportare, vista la effettiva difettosità che lo caratterizza.

- Resistenza a compressione;

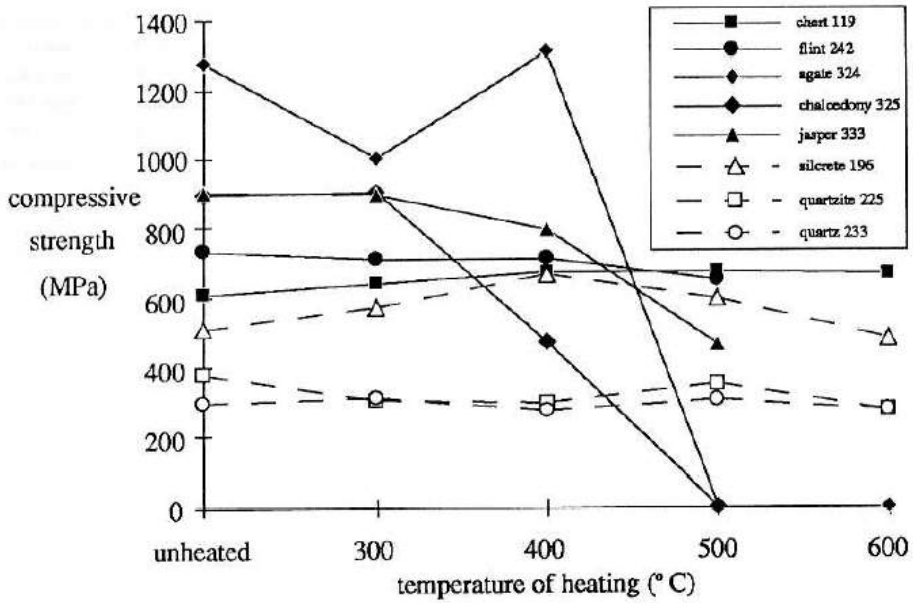


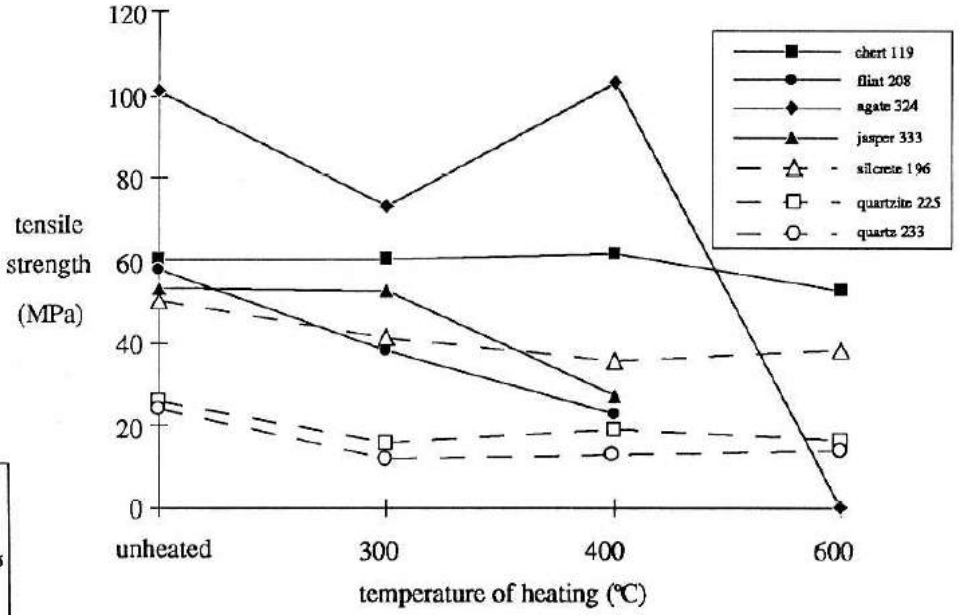


- Resistenza a trazione;

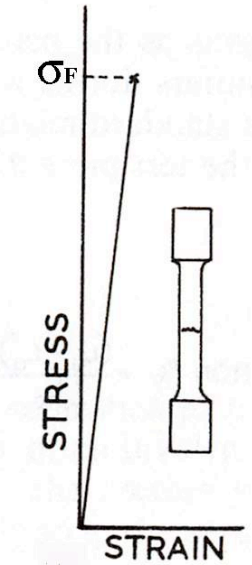


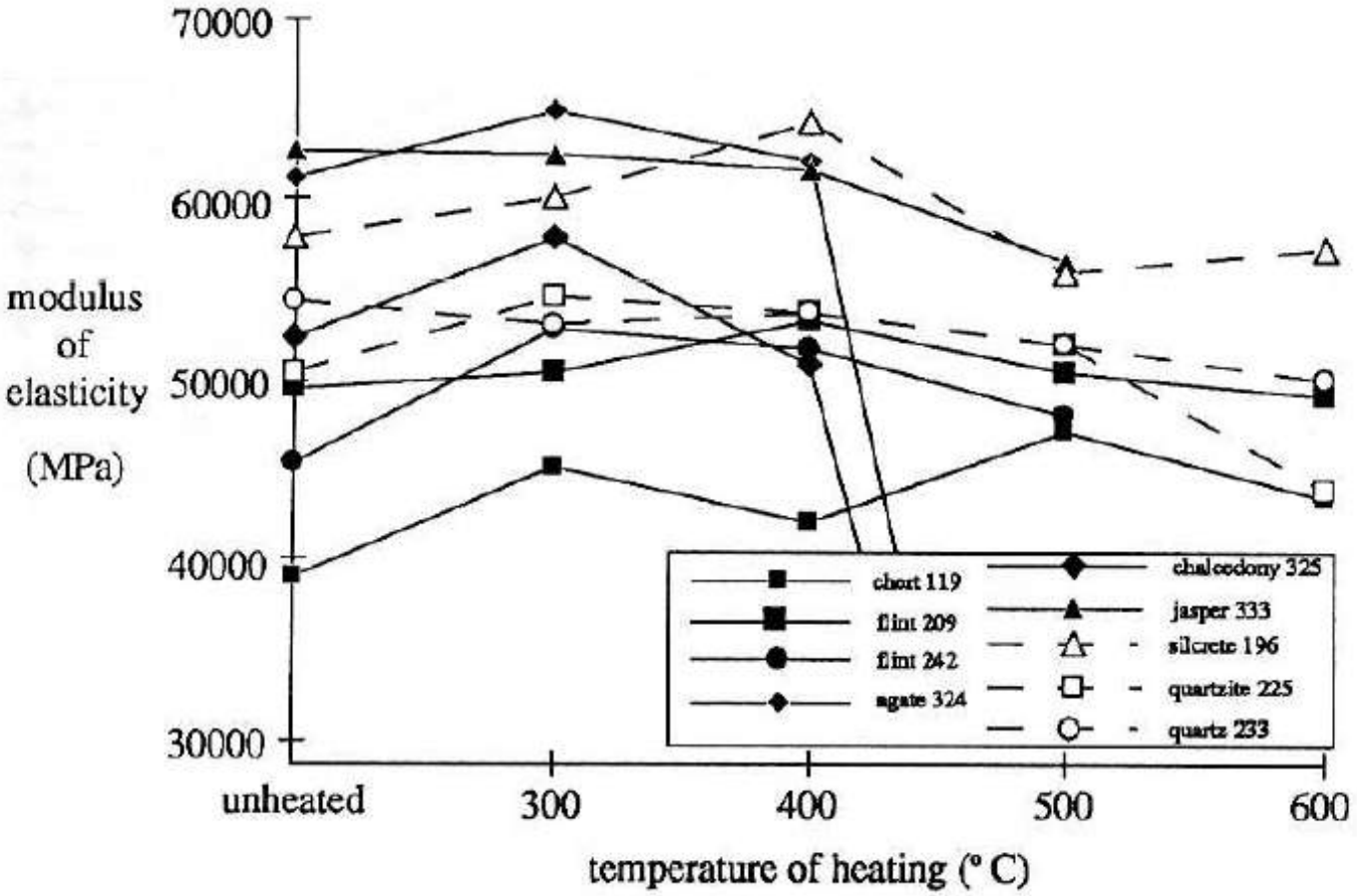
Compressione vs trazione



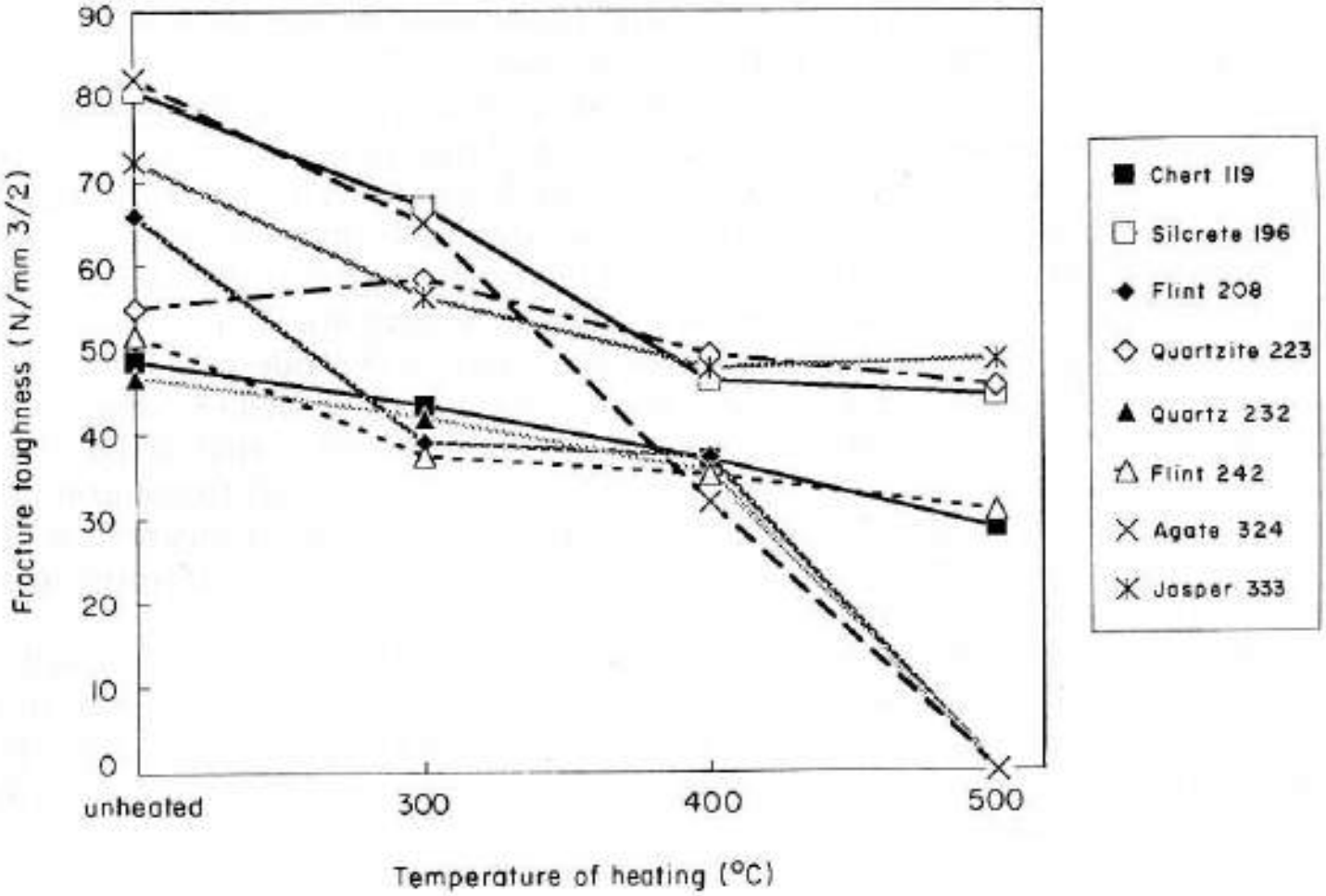


- Modulo elastico;



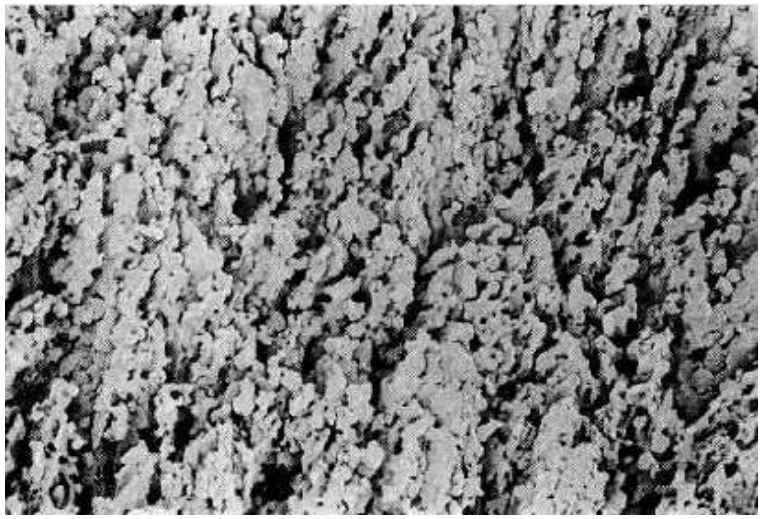


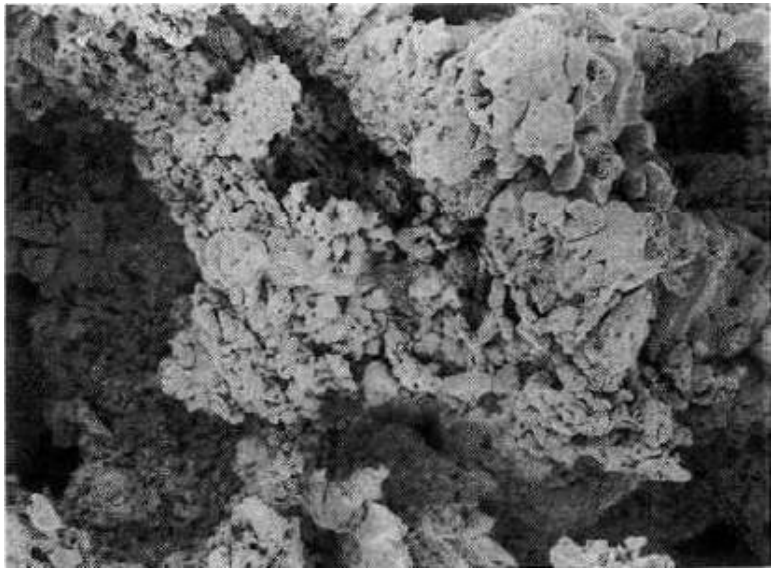
- Tenacità a frattura



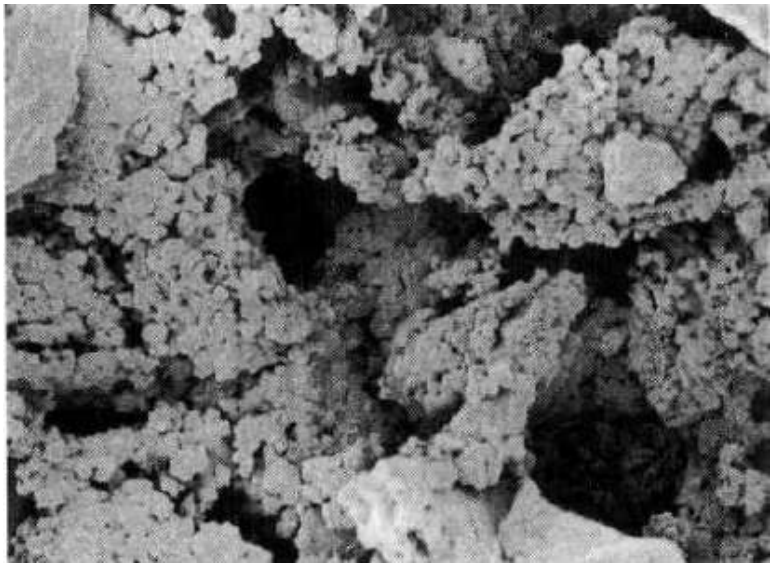
Microstruttura - riscaldamento

agata





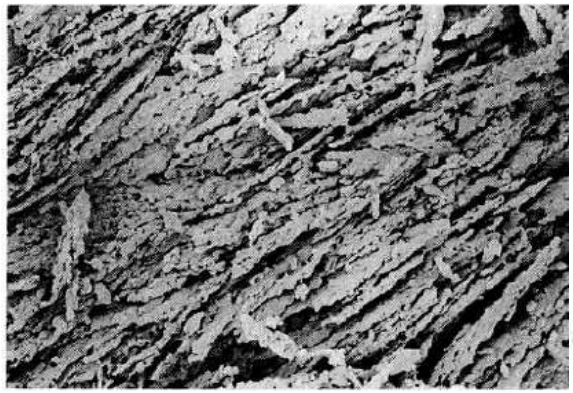
selce



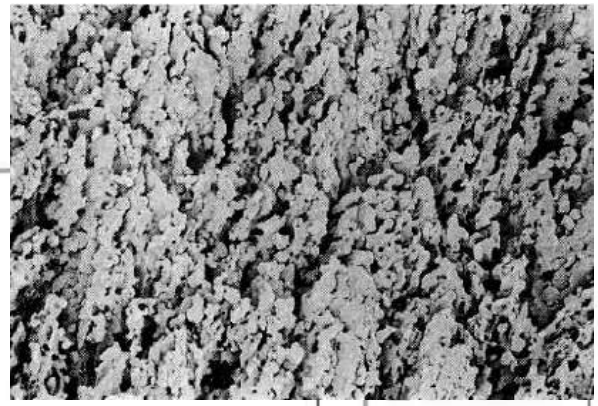
Tal quale

400 °C per 2 h

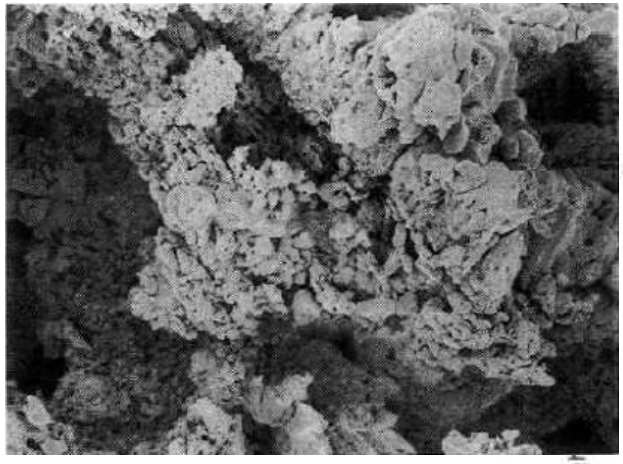
Microstruttura - riscaldamento



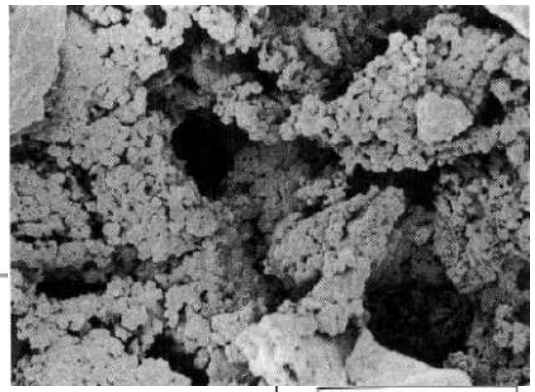
agata

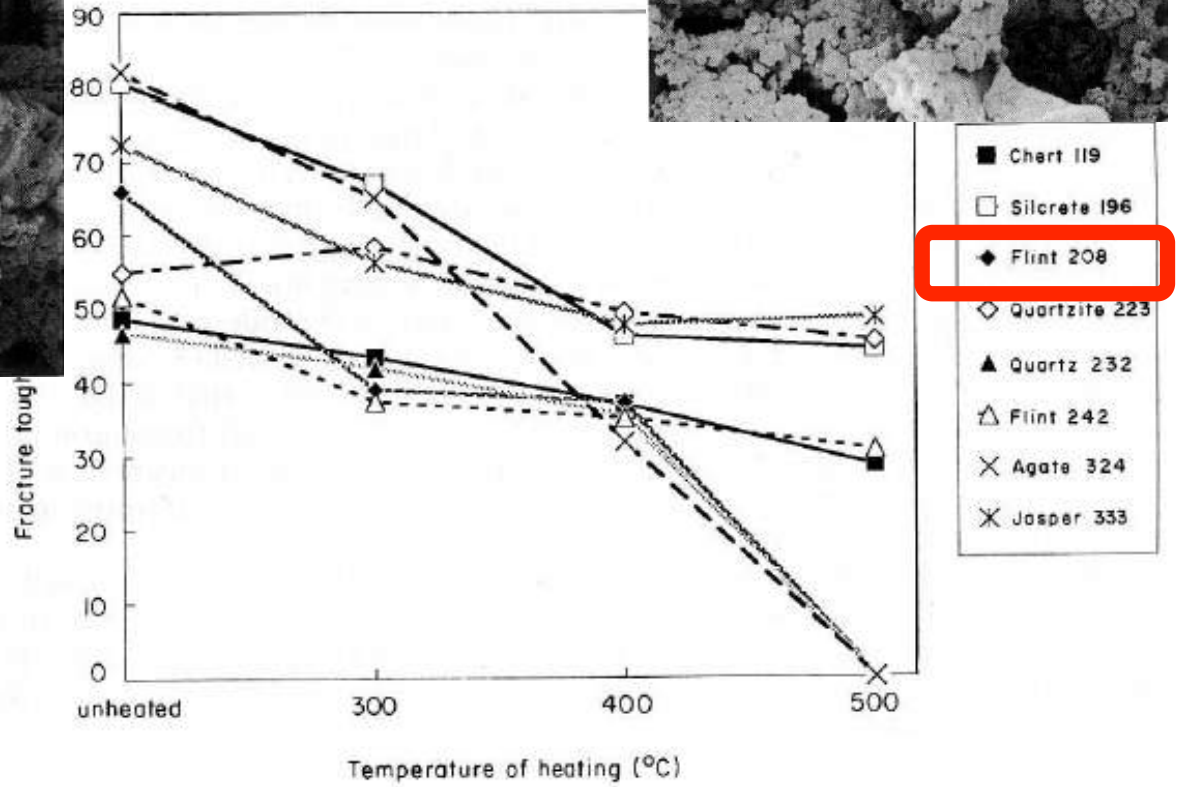


Microstruttura - riscaldamento



selce





Aspetti salienti dell'approccio "Domanski"

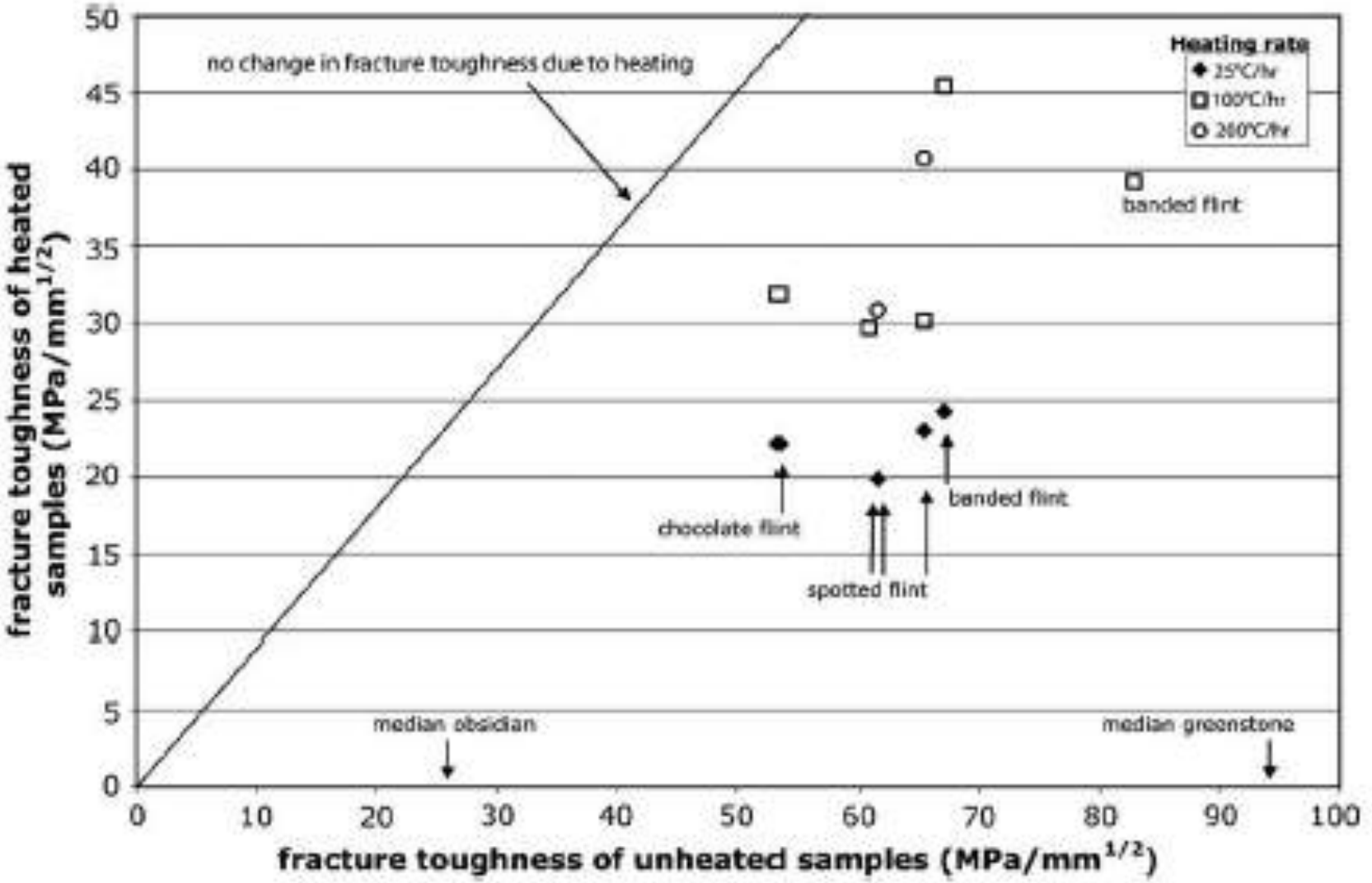
- Tenacità a frattura di un materiale a base silice sembra dunque essere ridotta dalla ricristallizzazione della grana cristallina indotta termicamente.

- …. Alla quale è associata una struttura dei difetti (pori, in particolare) più uniforme e di forma regolare (vedi "*effetto tratteggio*").

- Evidentemente una grana cristallina più regolare facilita la propagazione della frattura associata alla lavorazione per scheggiatura.

- Apparentemente, oltre alla temperatura di trattamento, altri parametri, tra i quali la velocità di riscaldamento, possono avere un ruolo nel modificare la tenacità a frattura dei materiali litici e quindi influenzarne la scheggiabilità .

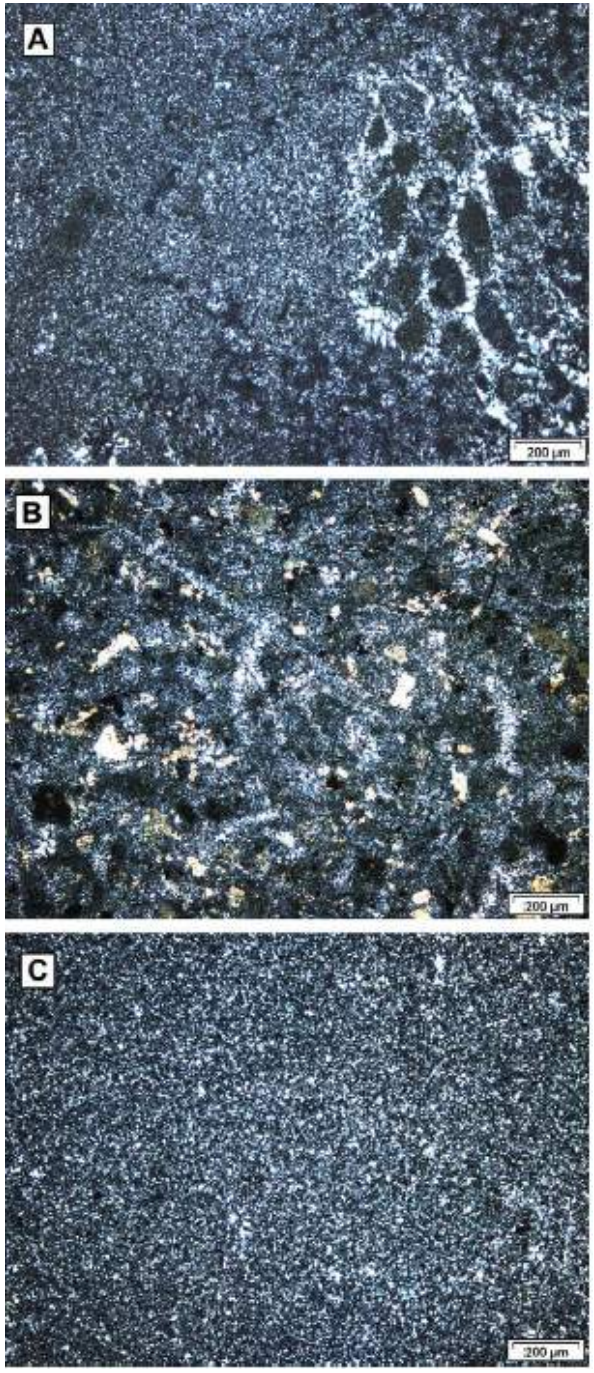
Tecnica - proprietà



Domanski M, Webb J, Glaisher R, Gurba J, Libera J, Zakoscielna A, Heat treatment of Polish flints, JAS, **36**, 1400-1408 (2009)

Selce cioccolata

(chocolate flint)



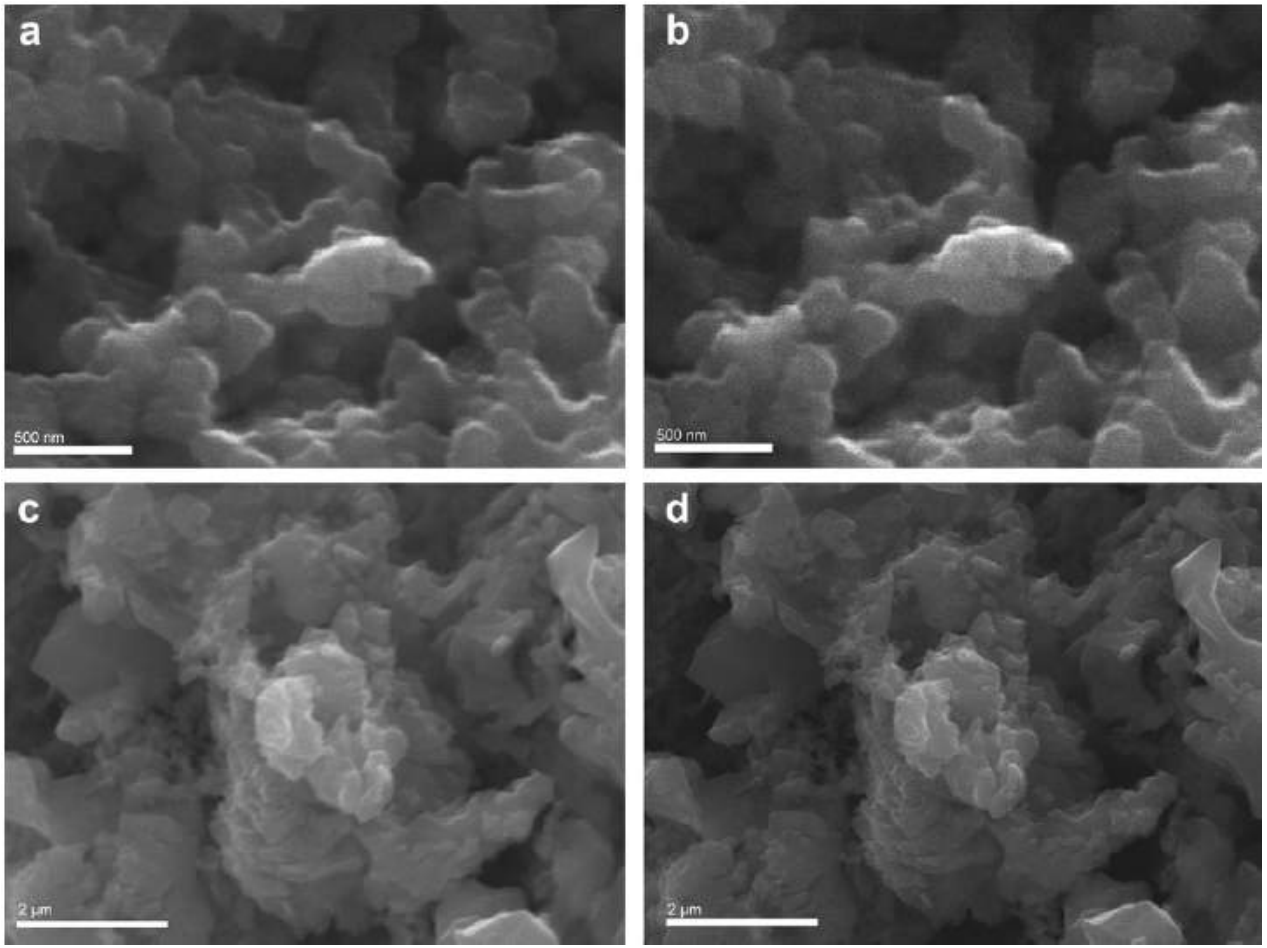
Selce maculata

(spotted flint)

Selce a bande

(banded flint)

Campioni di calcedonio



NO

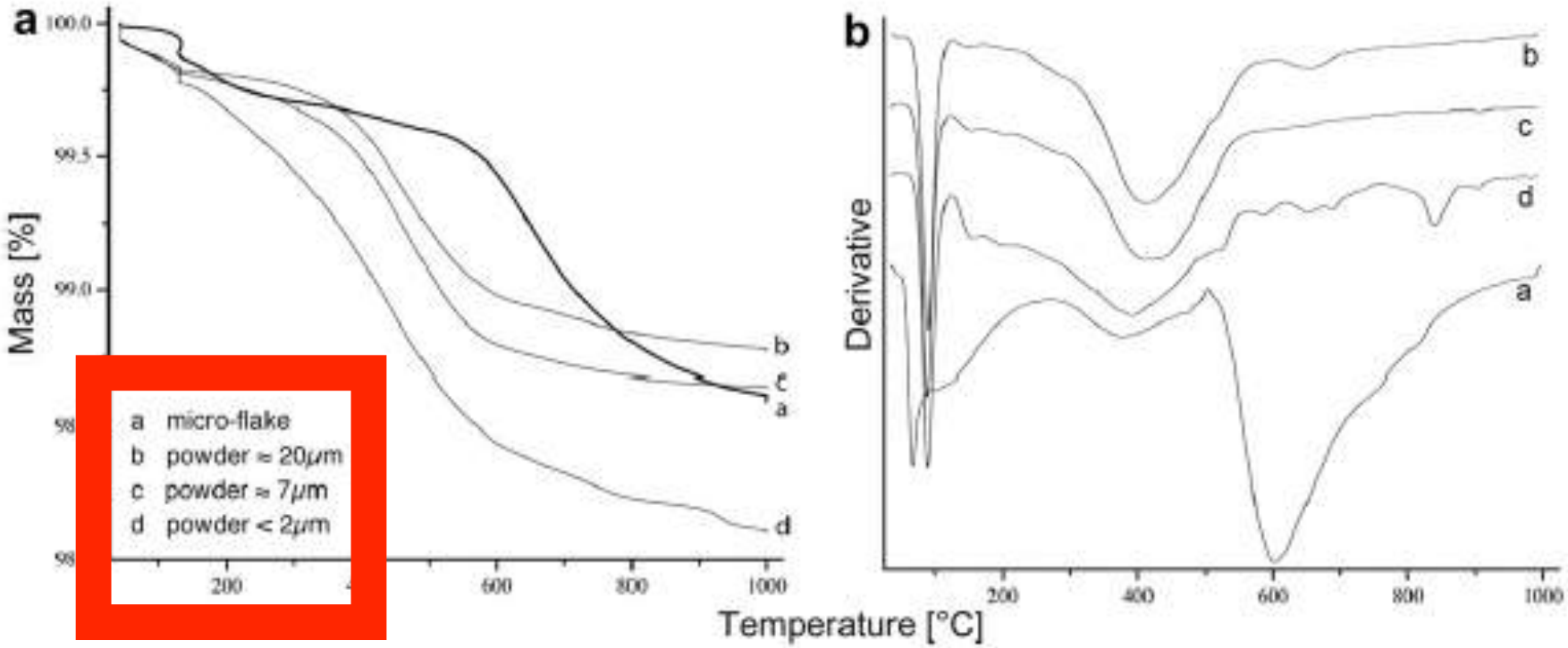
RICRISTALLIZZAZIONE

Prima **Dopo**

Trattamento a 450°C per 6 h – riscaldamento e raffreddamento a 2°C/min

Schmidt P et al., Crystallographic and structural transformations of sedimentary chalcedony in flint upon heat treatment, JAS, **39**, 135-144 (2012)

Tecnica - proprietà



Schmidt P et al., Crystallographic and structural transformations of sedimentary chalcedony in flint upon heat treatment, JAS, **39**, 135-144 (2012)

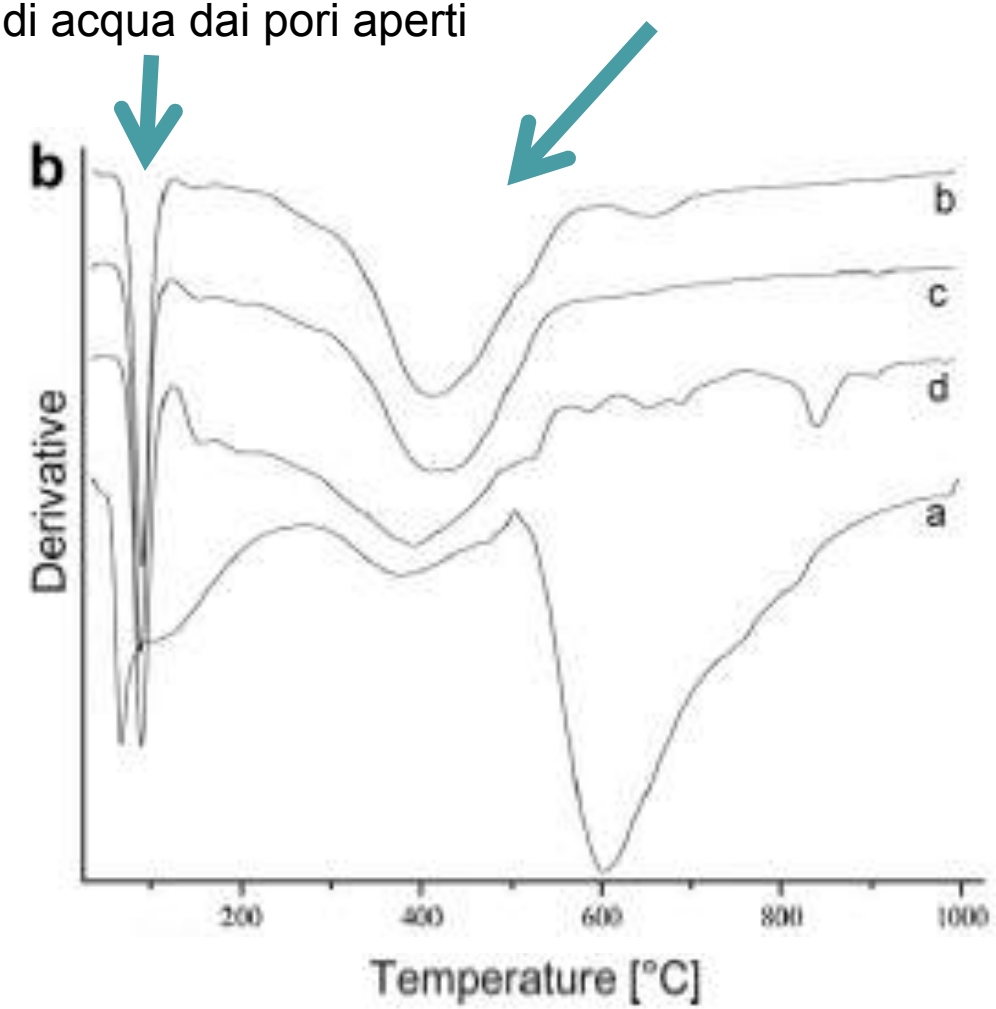
Tecnica - proprietà

Decomposizione del gruppo SiOH (silanolo)

Formazione di nuovi legami Si-O-Si

$$Si{-}OH\ HO{-}Si \rightarrow Si{-}O{-}Si + H_2O.$$

Rilascio di acqua dai pori aperti



a micro-flake
b powder ≈ 20μm
c powder ≈ 7μm
d powder < 2μm

Schmidt P et al., Crystallographic and structural transformations of sedimentary chalcedony in flint upon heat treatment, JAS, **39**, 135-144 (2012)

Tecnica - proprietà

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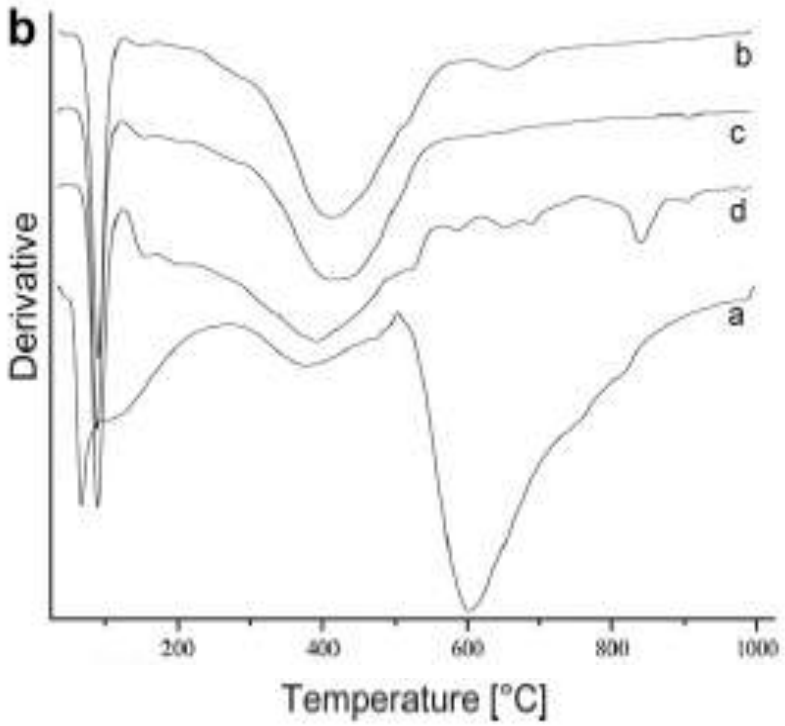

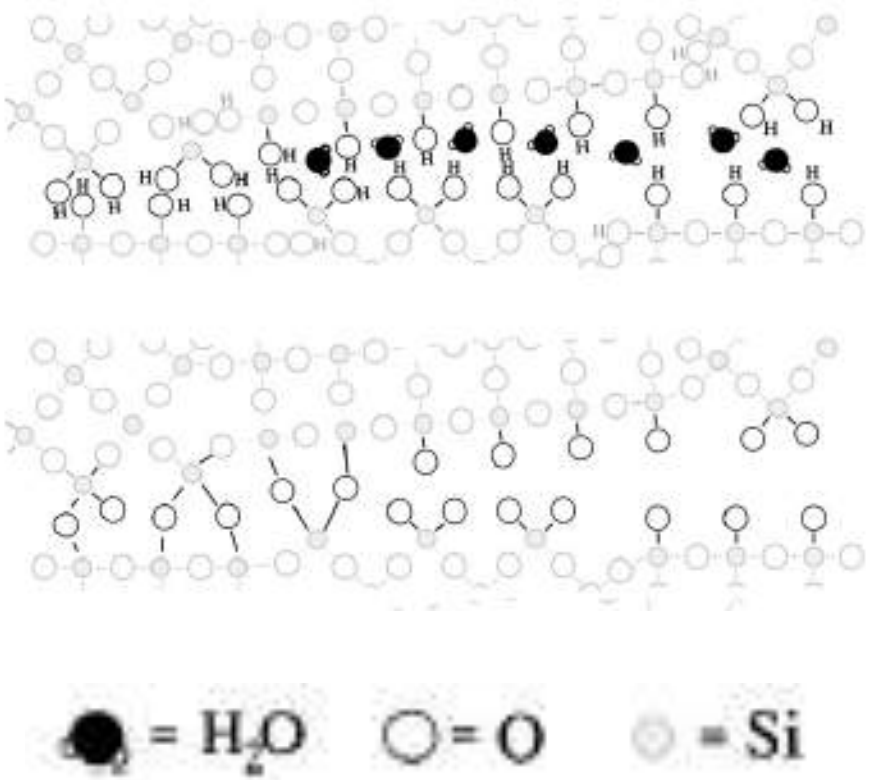

Schmidt P et al., Crystallographic and structural transformations of sedimentary chalcedony in flint upon heat treatment, JAS, **39**, 135-144 (2012)

Tecnica - proprietà

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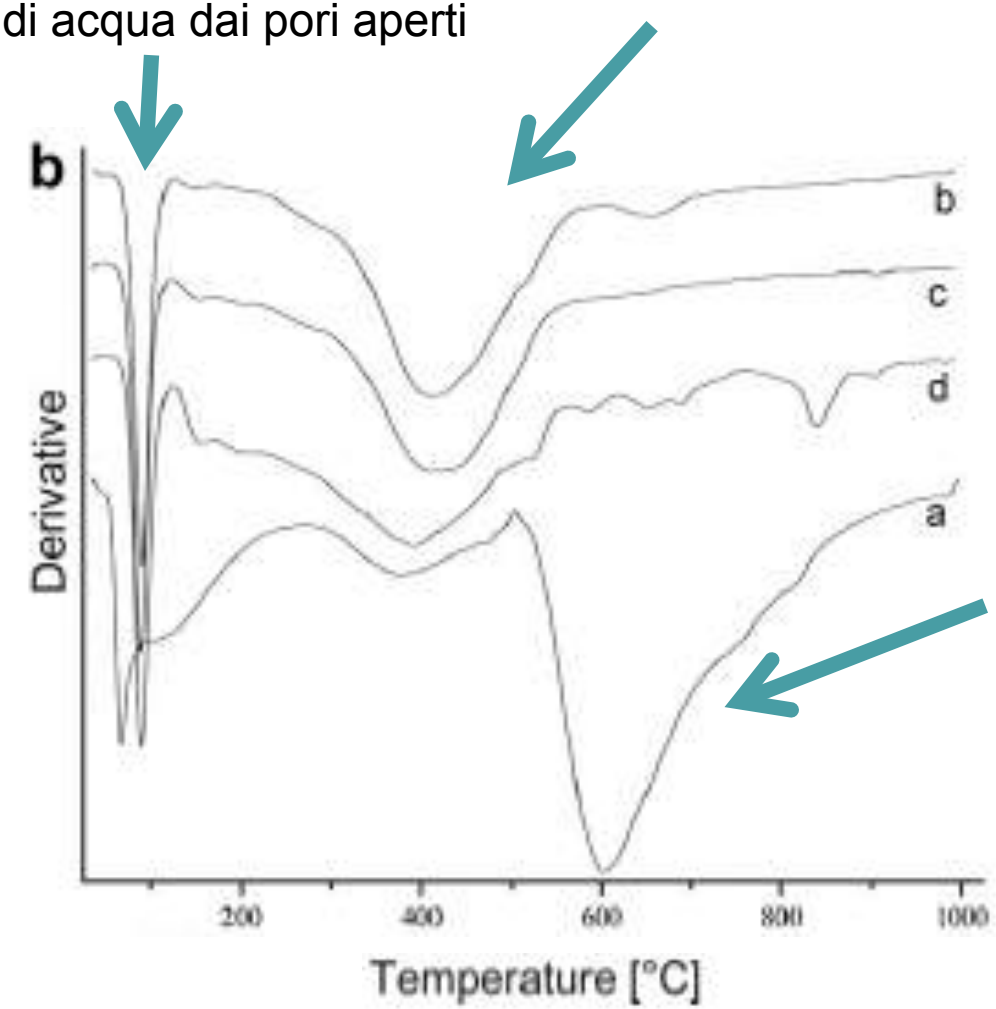
Rilascio di acqua dai pori aperti



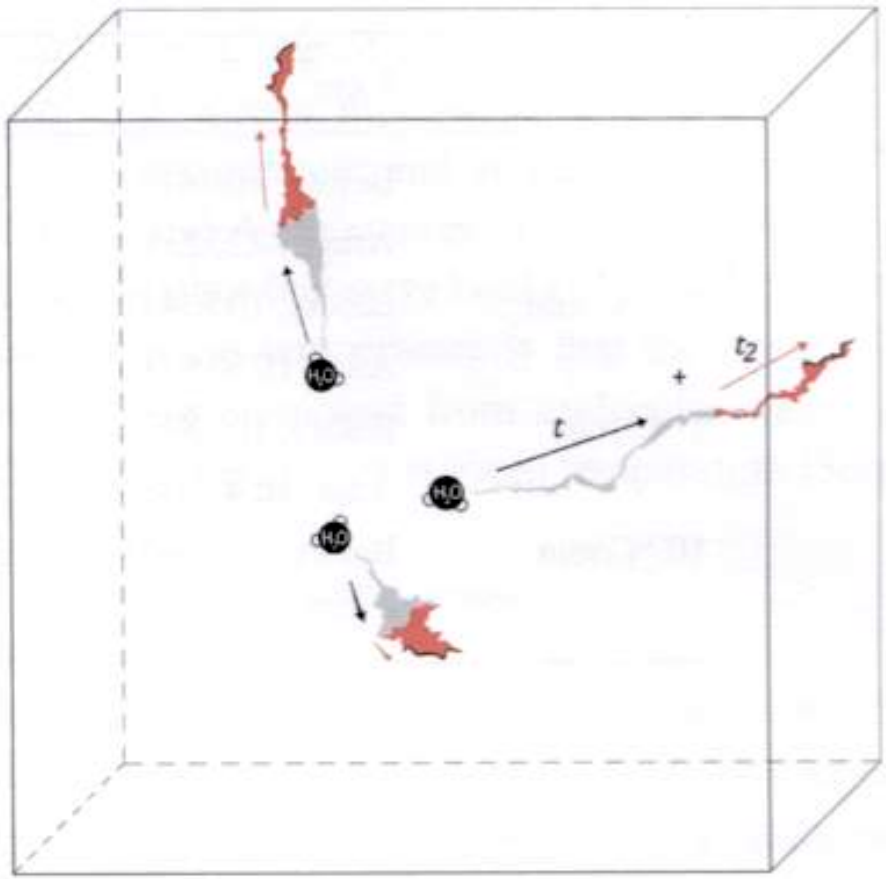
a micro-flake
b powder ≈ 20μm
c powder ≈ 7μm
d powder < 2μm

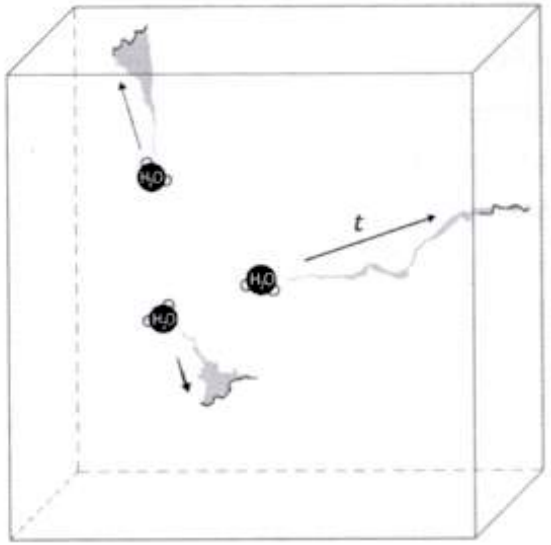
Rilascio di acqua dai pori chiusi

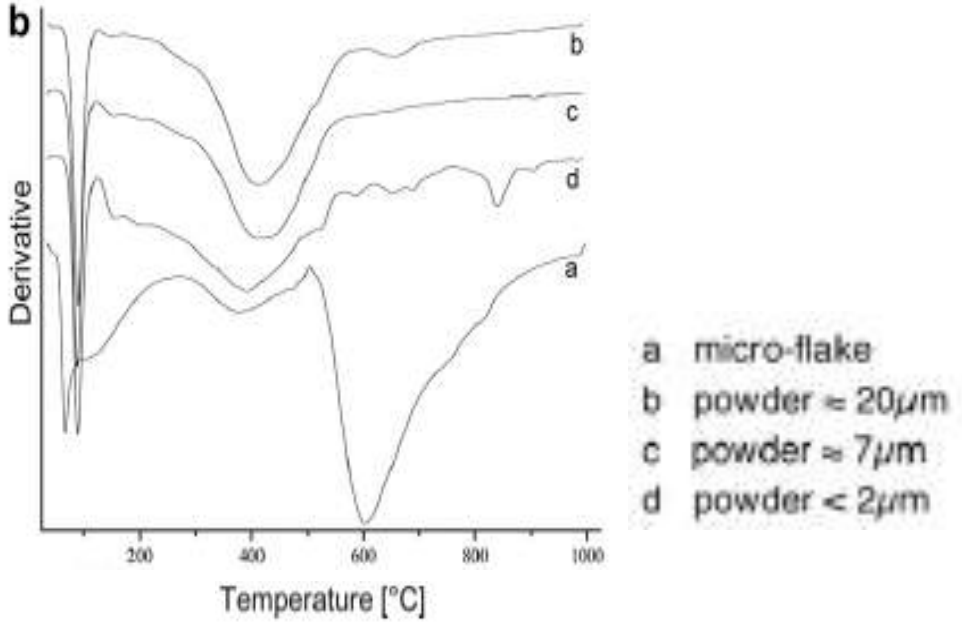
con frammentazione del materiale

Schmidt P et al., Crystallographic and structural transformations of sedimentary chalcedony in flint upon heat treatment, JAS, **39**, 135-144 (2012)

Tecnica - proprietà



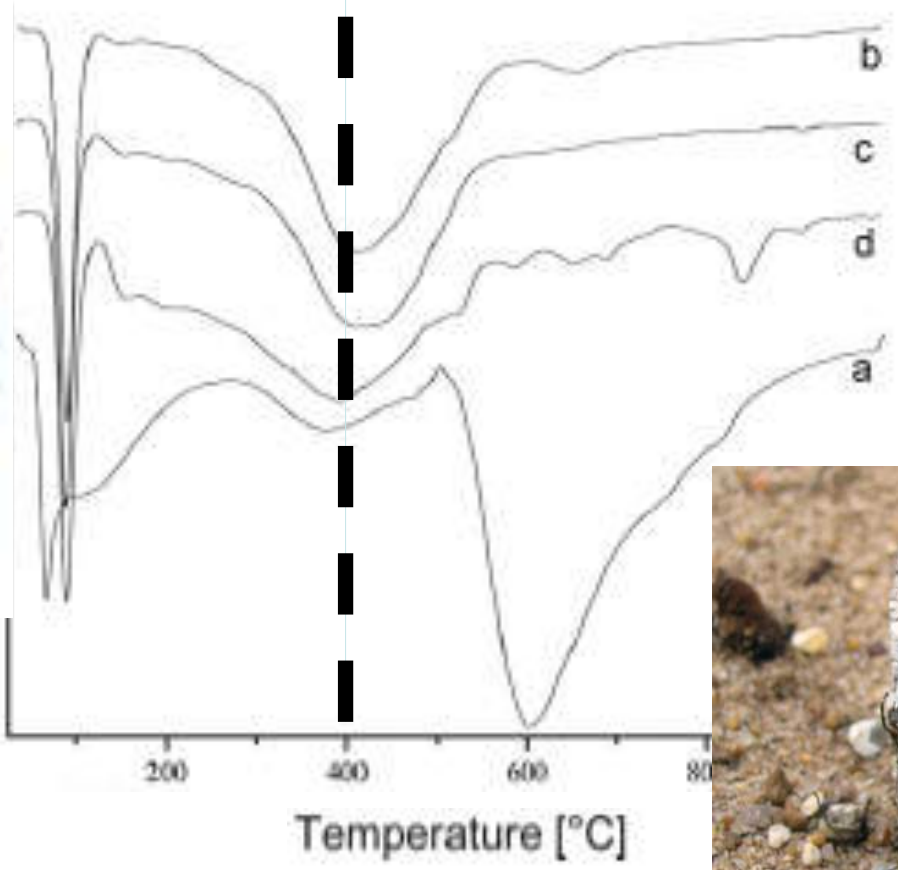




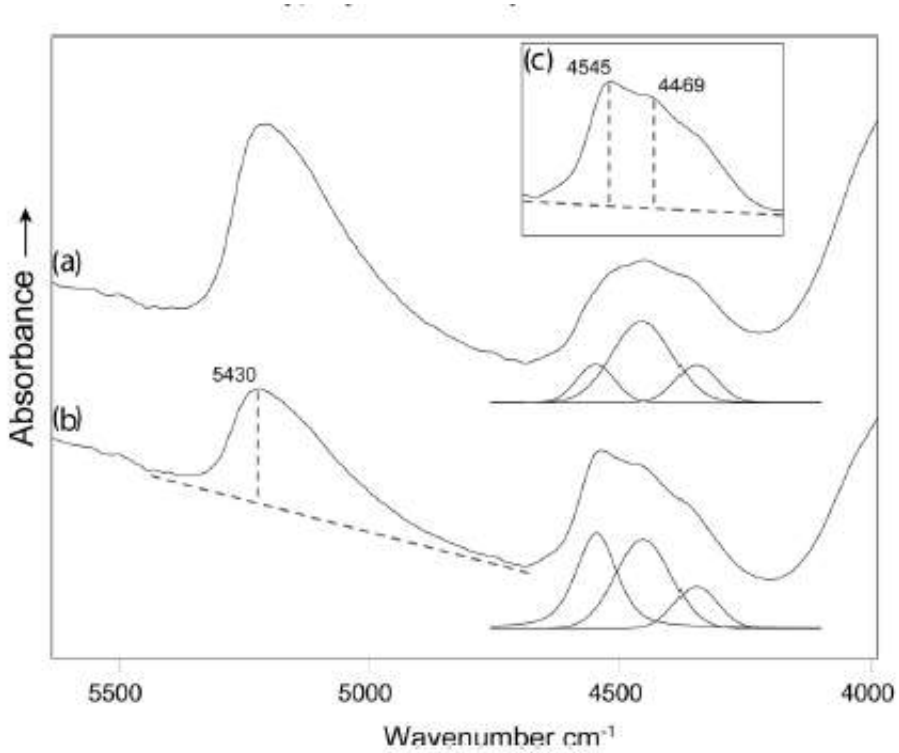
Schmidt P., What causes failure (overheating) during lithic heat treatment?, AAS, **6**, 107-112 (2014)

Selce scaldata

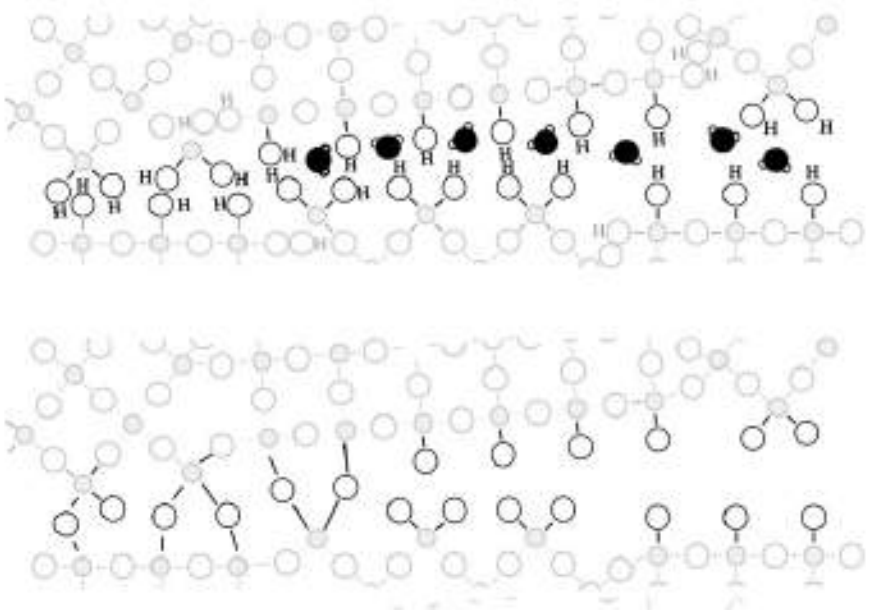
Selce bruciata



Tecnica - proprietà



Hydrated



Dehydrated

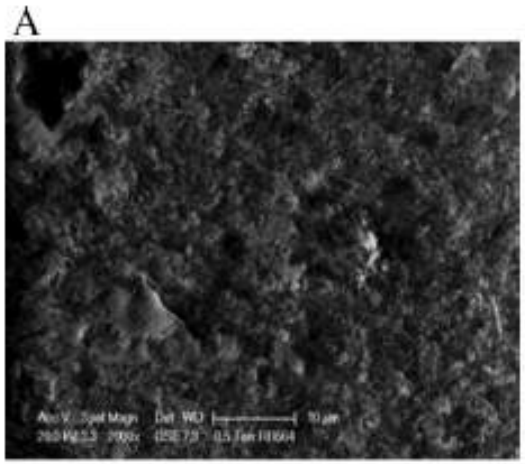
Schmidt P. et al., Detecting and Quantifying Heat Treatment of Flint and Other Silica Rocks.

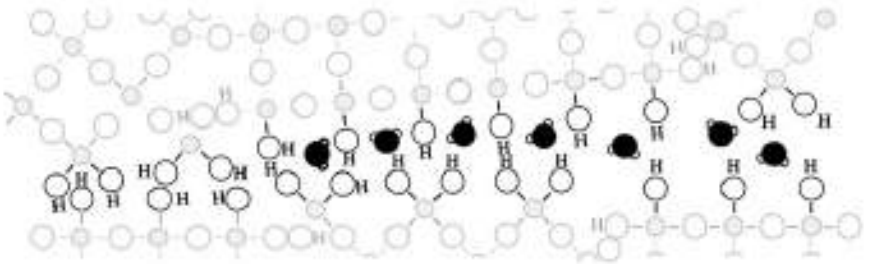
Archaeometry **55** (2013) 794–805

Tecnica - proprietà

Selce non scaldata

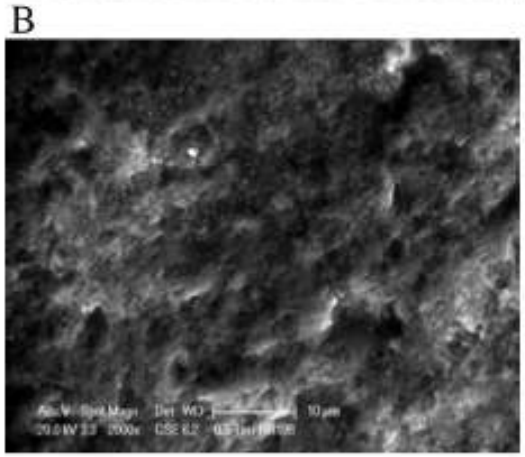
(*campione scheggiato)*

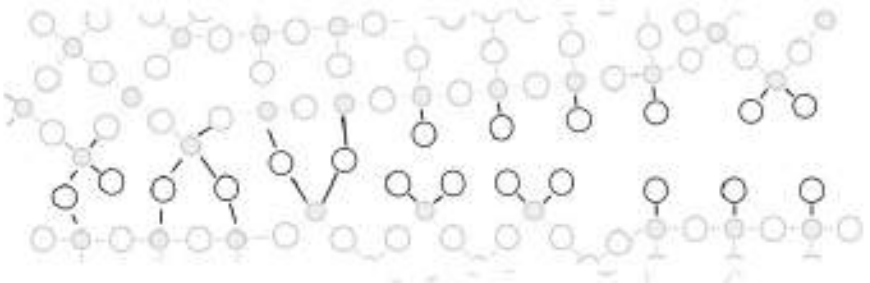




Selce scaldata

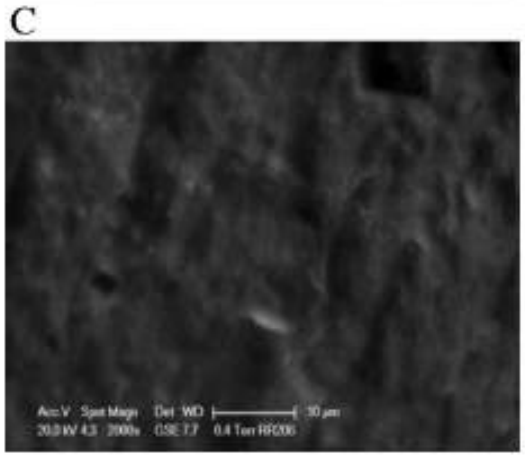
(*campione scheggiato)*





Selce scaldata

(*nodulo scheggiato)*



F.Santaniello, S. Grimaldi, A. Pedrotti, S. Gialanella,,Quaternary International (2015)