NATURAL POZZOLANS

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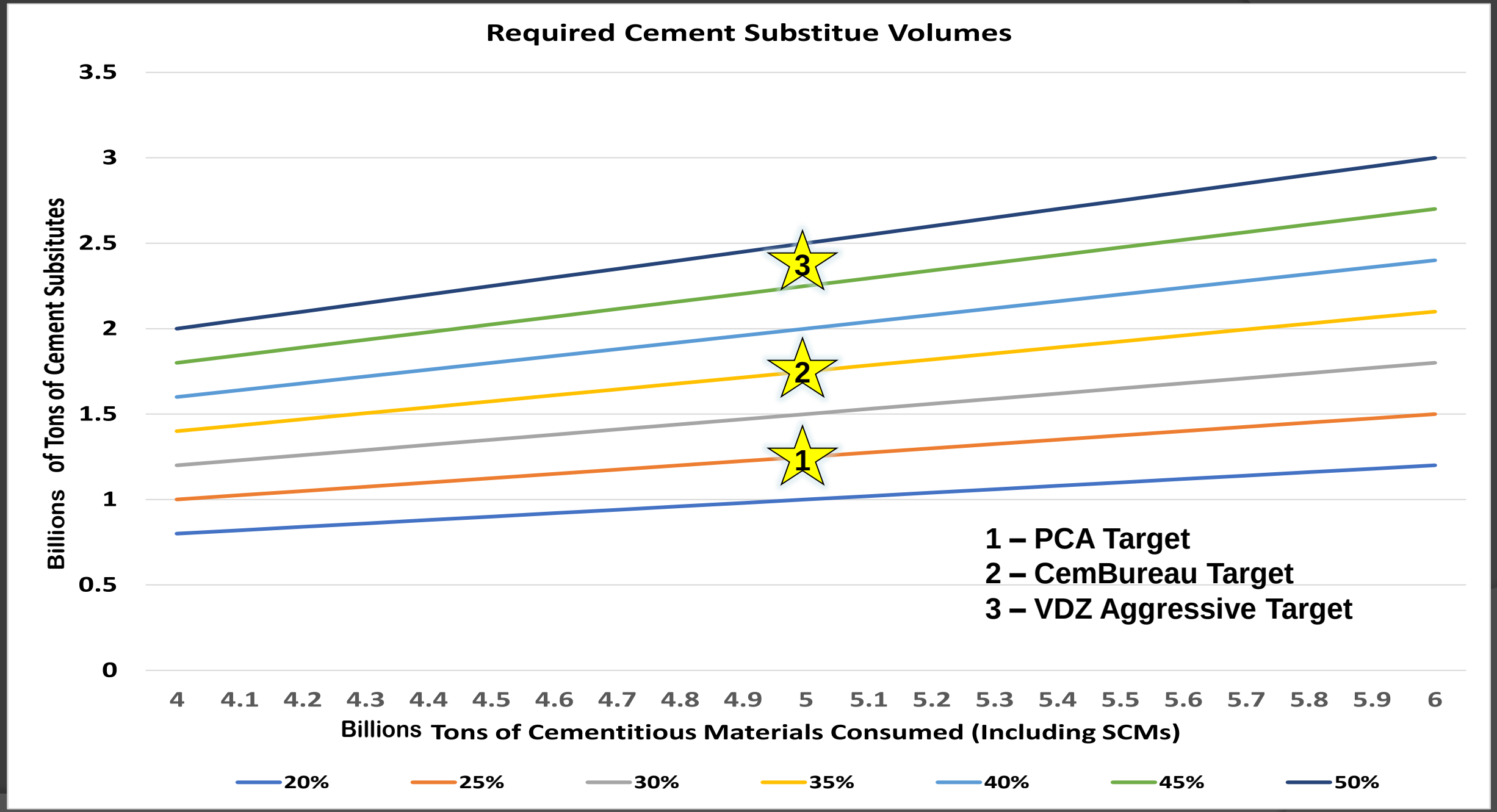
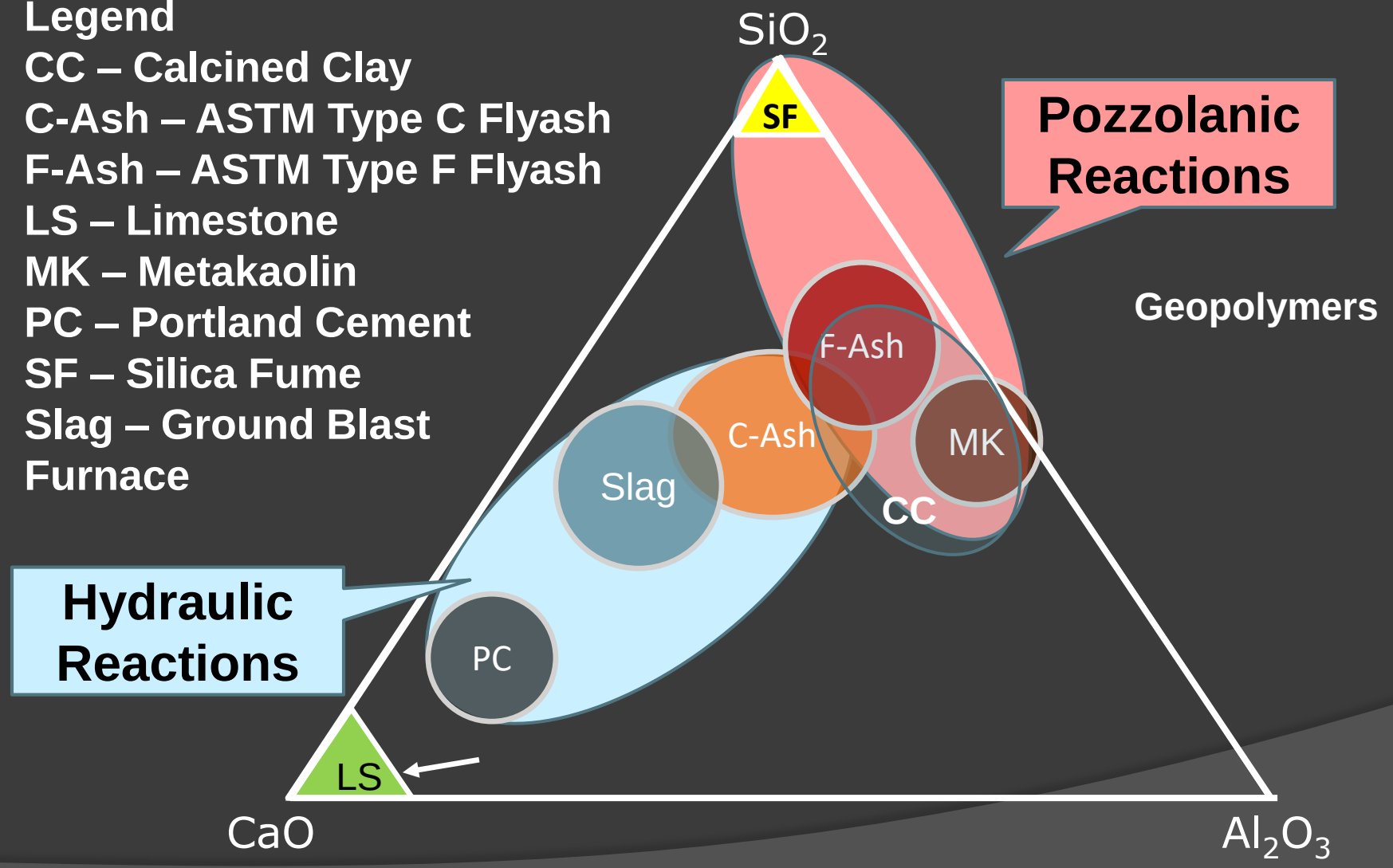


Supplemental Cementitious Materials

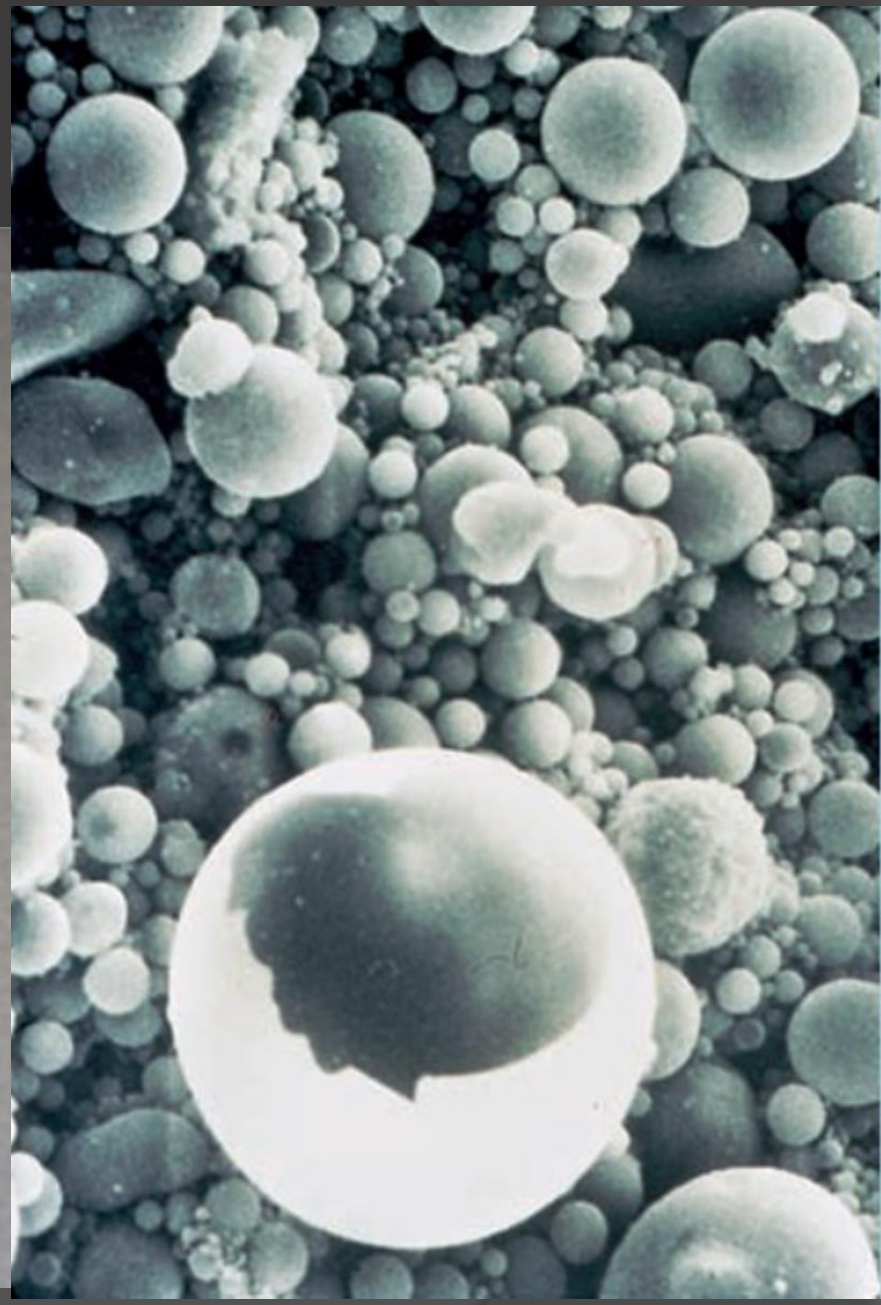
- Traditional SCMs
  - Slag
  - Fly Ash
  - Pozzolans
- New SCMs
  - Calcined Clay
  - Harvested Fly Ash
- Drivers for SCM use
  - Cost
  - CO2 emissions reductions
  - “Green” Products

Most Important Binder Materials

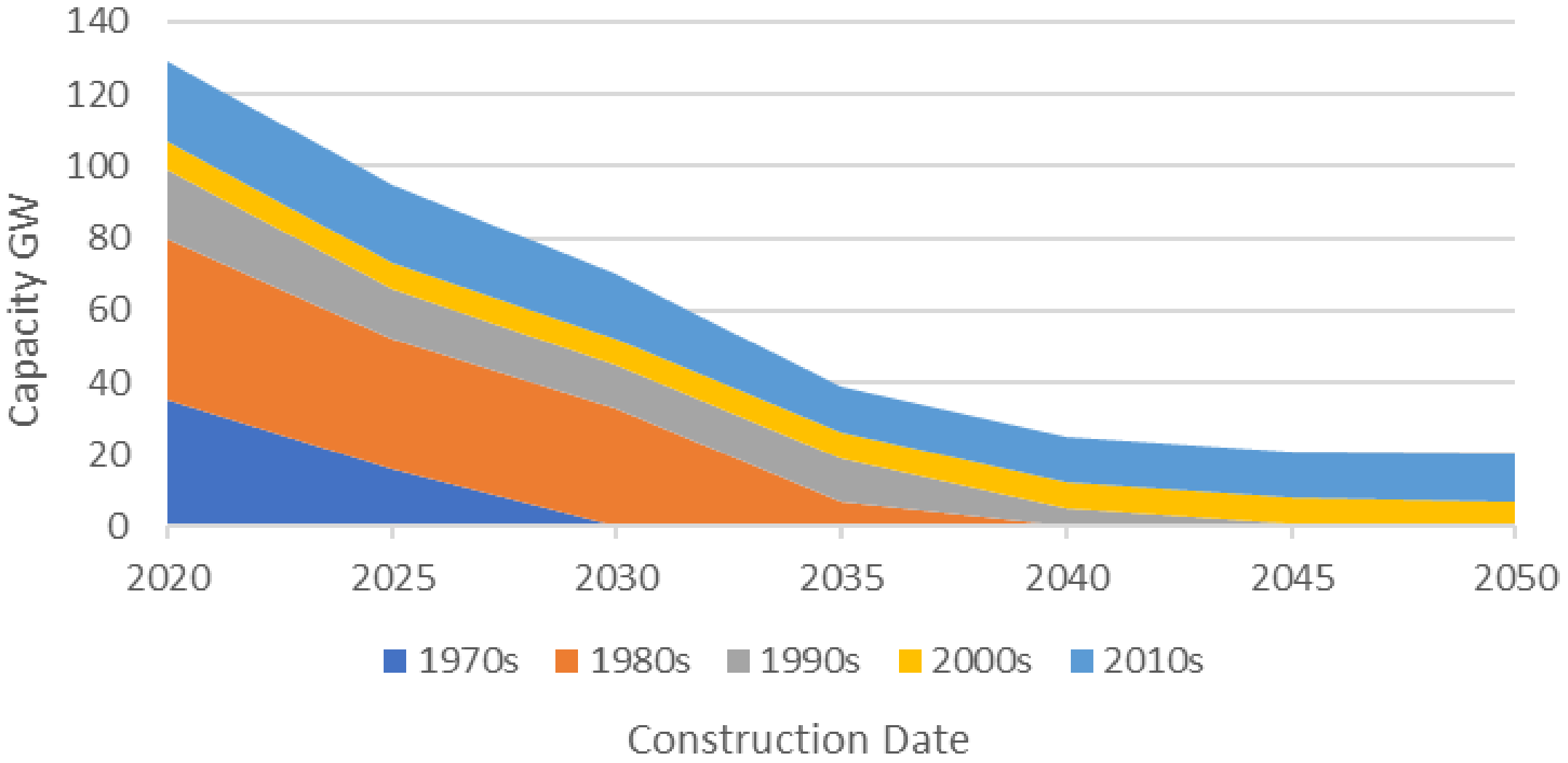
Legend
CC – Calcined Clay
C-Ash – ASTM Type C Flyash
F-Ash – ASTM Type F Flyash
LS – Limestone
MK – Metakaolin
PC – Portland Cement
SF – Silica Fume
Slag – Ground Blast Furnace



Fly Ash



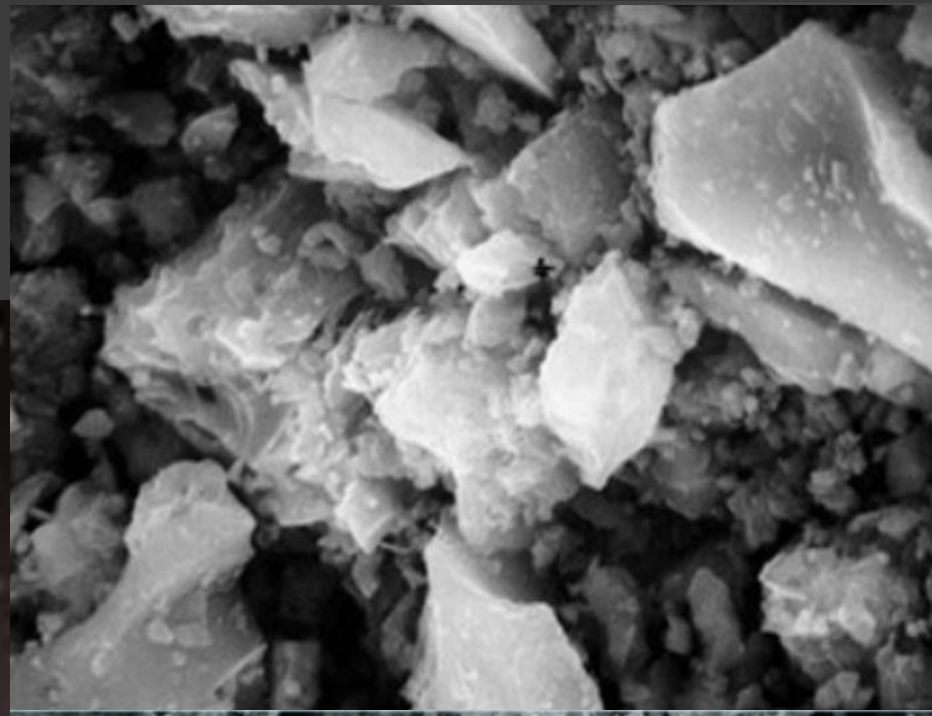
US Coal Fleet Capacity Trajectory

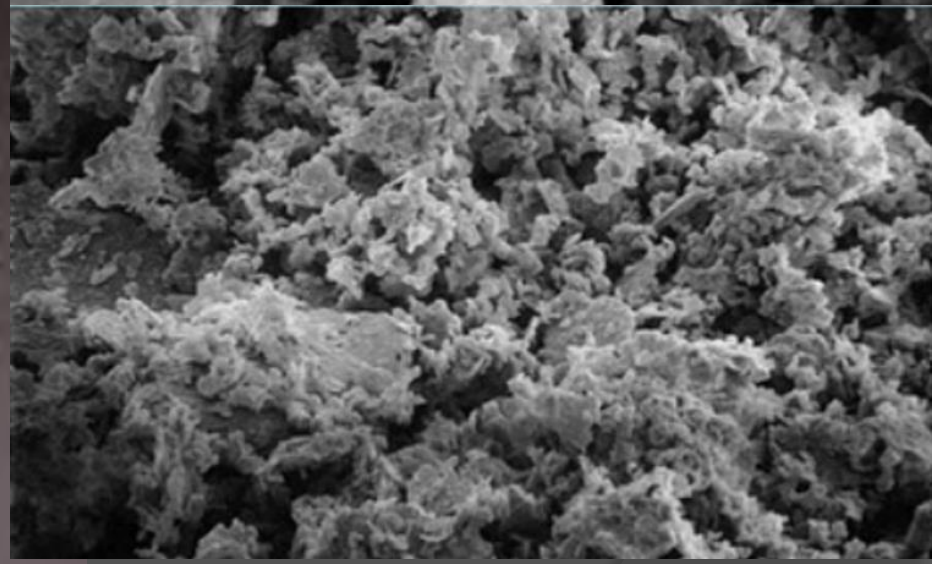


Fly Ash Harvesting

- The term “Harvesting” was selected for ease of regulations
- Companies that are harvesting fly ash
  - Separation technologies
  - Eco Materials
  - Salt River Materials Group
  - Charah
  - SEFA
  - AshCor

Natural Pozzolans





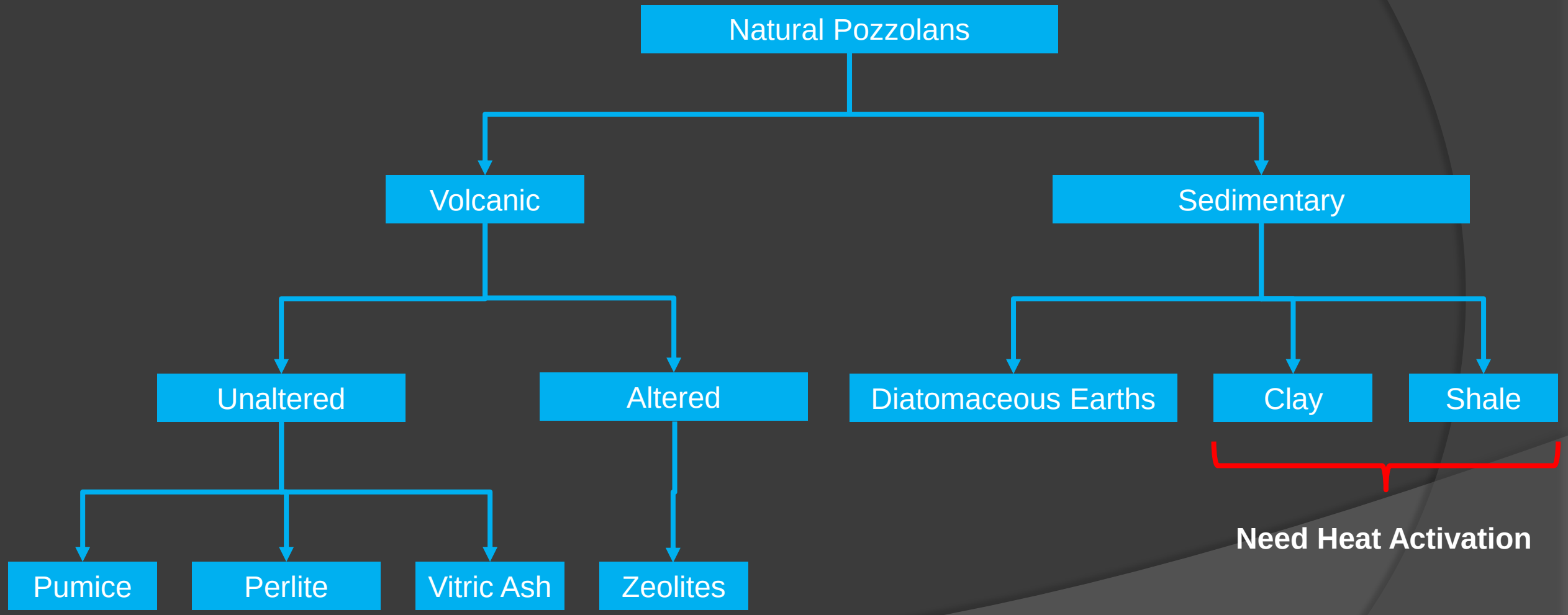
Natural Pozzolans

- Applicable Standard – ASTM C618, Class N
  - Calcined shale
  - Calcined clay
  - Volcanic ash
- Where cementitious or pozzolanic action, or both, is desired
- The materials shall be tested for fineness, strength activity index, water requirement, soundness, and autoclave expansion or contraction.

Natural Pozzolans

- Have been used in cements for millennia
- Sourced from volcanically active areas
- Fresh volcanic ash the most reactive
- Widely used along Pacific coast of South America
- Gaining momentum in North America
- Several mines starting in Southwest, but reactivity low
- Operation similar to fly ash harvesting
- Mining costs on order of $25 – 40 per ton depending on need for heat treatment

Natural Pozzolans



Natural vs Artificial Pozzolans

Natural:

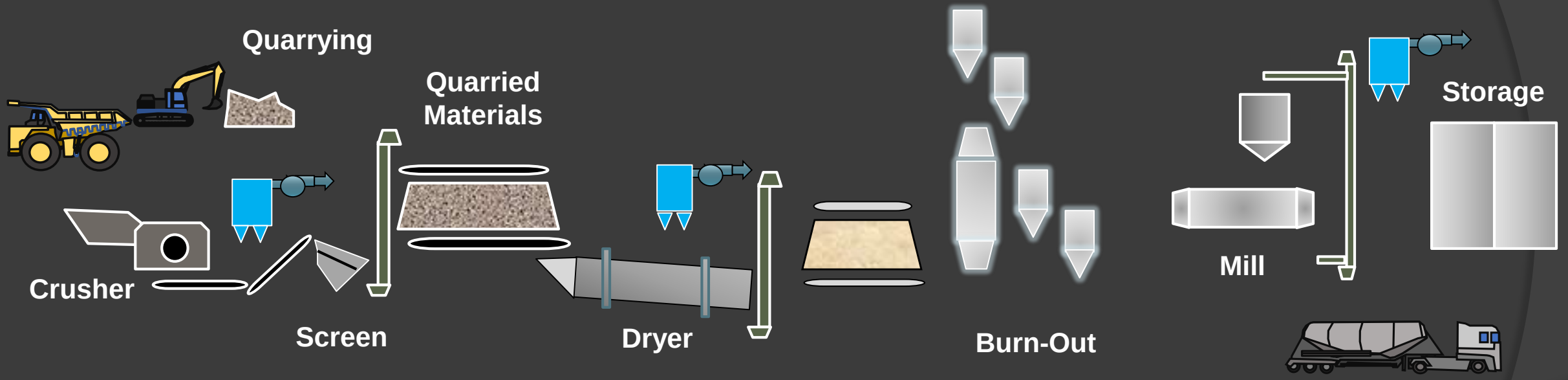
- Natural sources
- Mined and sized
- Thermal processing for drying only (if required)
- Lower carbon footprint
- Less capex

Artificial:

- Reclaimed sources
- Mined and sized
- Thermal processing required for drying and possibly activation
- Higher carbon footprint
- Higher capex

Natural Pozzolan Mining

Fly Ash Harvesting / Natural Pozzolans



$10 – 50 million depending on size and complexity
Typically 100,000 ton per year range

Natural Pozzolan Companies & Main Business

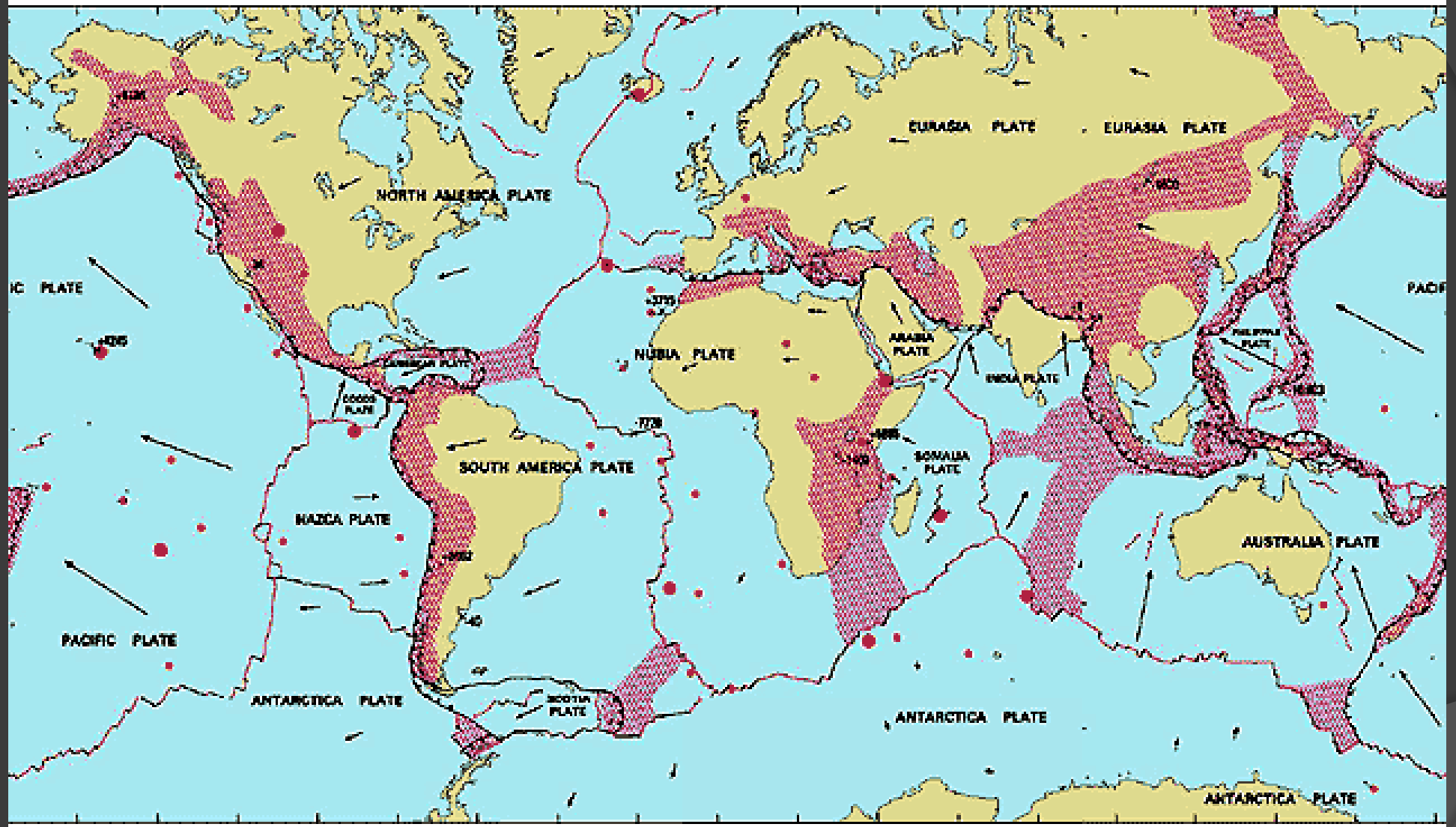
- Boral (Kirkland) – Fly Ash
- Salt River Materials Group - Cement
- Eagle Materials - Cement
- Charah – Fly Ash
- Hess - Pumice
- CR Minerals - Pozzolans
- Geofortis - Pozzolans
- Fortera - Pozzolans

Natural Pozzolans Approved in California

Caltrans		Listed Pozzolans	Natural Pozzolan (CaO<10%)	AASHTO M 295	
Country	**Source**	**Suppliers Name**	**Product Name**	**Source Name**	**Source Location**
US	CA	3M	NP200C Pozzolan	3M Corona	Corona, CA
US	AZ	Boral Resources	Kirkland Natural Pozzolan	Kirkland Mine	Skull Valley, AZ
US	CA	Diversified Minerals Inc.	Global Pozzolan	Global Pumice	Olancha, CA
US	CA	Geofortis Pozzolans, LLC	GEO NP2 Pozzolan	Geofortis Pozzolans	Doyle, CA
US	UT	GEOFORTIS Utah, LLC	Utah Natural Pozzolan	Geofortis Utah Plant	Toole, UT
US	CA	Golden State Crushing	GSP Class N Pozzolan	Golden State Pozzolan	Ione, CA
US	NV	KMI Zeolite Inc.	Clinoptilolite Zeolite	KMI Zeolite	Amargosa Valley, NV
US	NV	Nevada Cement Company	Fernley Class N Pozzolan	Fernley Plant	Fernley, NV
Indonesia		Peakward Enterprises (Holdings) Ltd.	Peakward Pozzolana	Peakward Quarry	Indonesia
			Provisional Acceptance		

https://mets.dot.ca.gov/aml/CementitiousList.php

ACTIVE VOLCANIC CENTERS WORLDWIDE



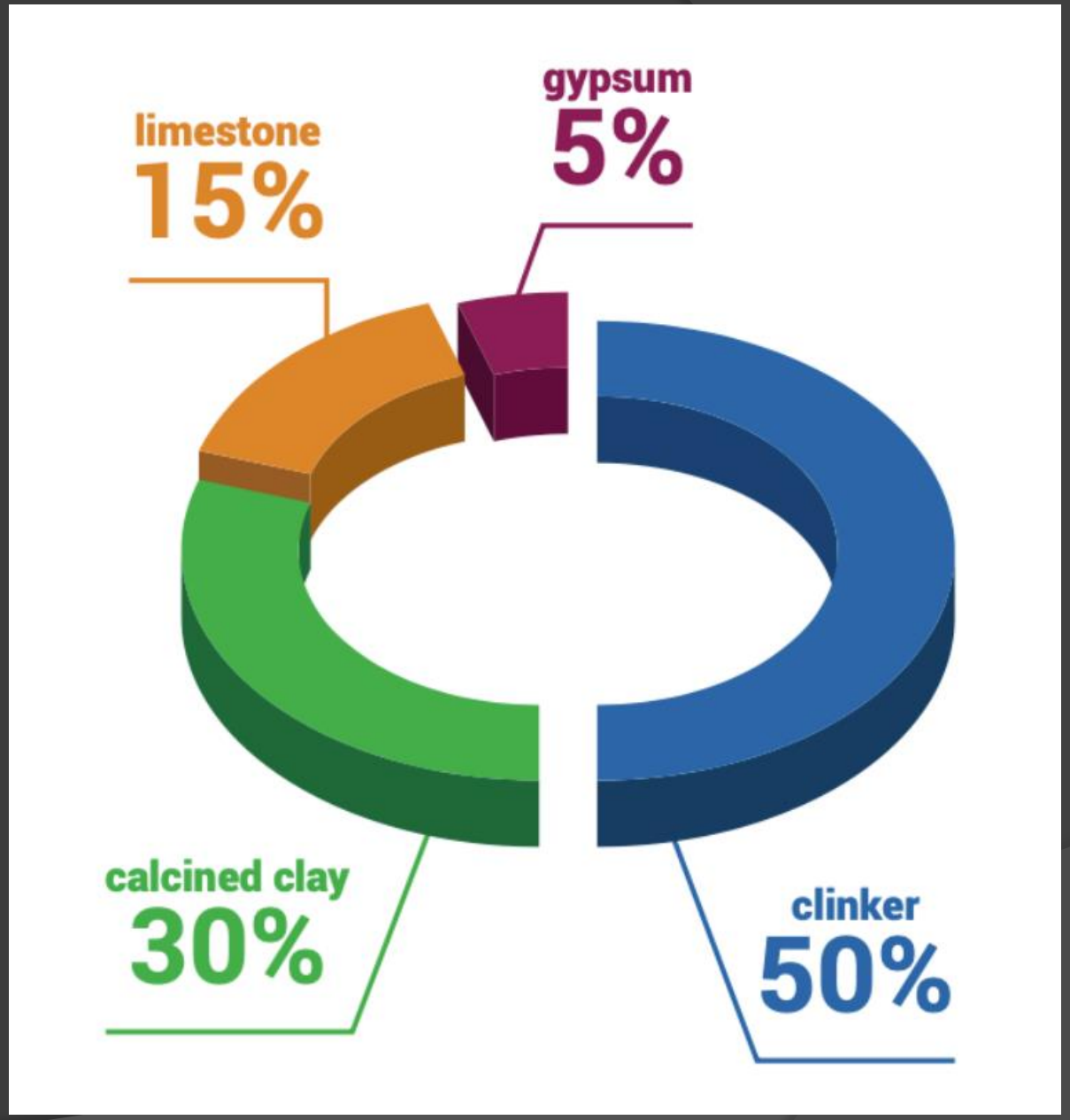
Natural Pozzolans Summary

- The loss of flyash supplies has increased interest in natural pozzolan usage
- Several pozzolan mines are starting operation, mostly in the US southwest
- To date, small amounts have been quarried and utilized, but interest is continuing
- It is estimated that less than 1 million tons have been quarried to date for cement substitute purposes
- Natural pozzolans will have to be certified in the same manner as new and existing fly ash sources
- US Market area will probably be limited to the southwest due to transport costs
- Global Market will focus on areas of volcanic activity

Calcined Clay & LC3

Limestone, calcined clay cement

- Developing specifications in Europe
- Has a lot of momentum in Europe
- UNEP support
- Most likely will require a specification change
- No movement as yet in North American



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