

Ministry Of Higher Education and Scientific Research

Salahaddin University / College of Science

Department of Chemistry



# Geochemistry and Mineralogy

**Dr. Idrees N. Ahmed**

**Assist. Prof. Dr. Awaz Karim**

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# Lecture 5

# Geochemistry of Igneous Rocks

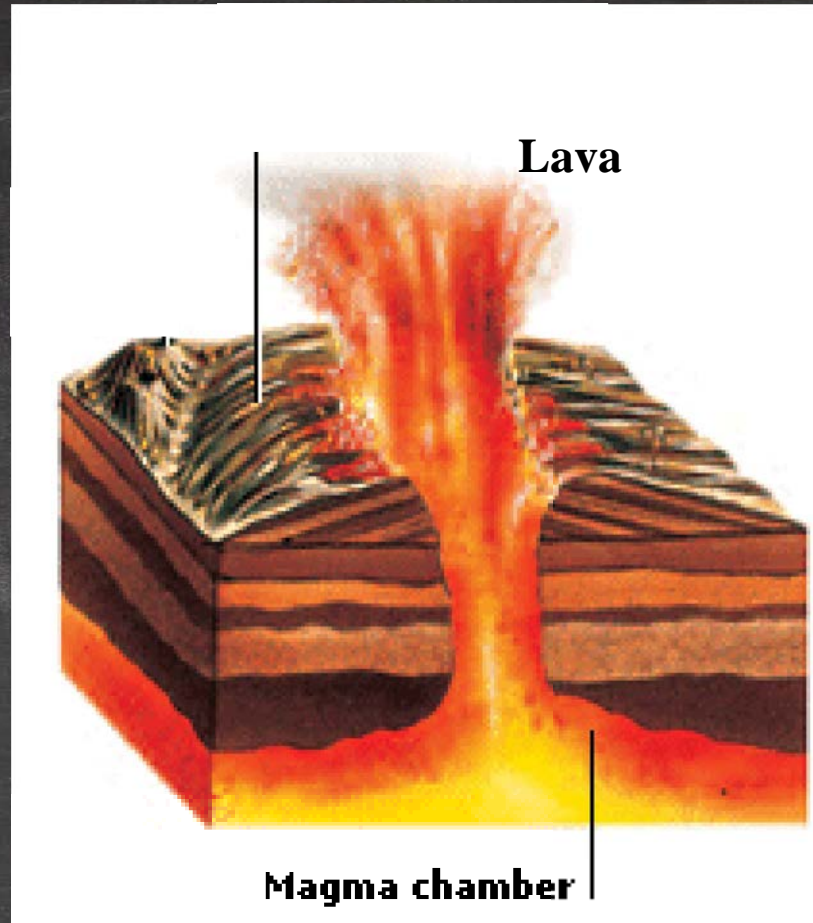


## 1. Terms:

**Volcano:** A gap in the Earth's Crust where molten rocks and other material escape onto the Earth's surface, the ascent of magmas through the mantle may be slow or rapid (0.3 – 50 m/year).



**Lava:** magma on the Earth's surface.



**Magma:** molten rock below Earth's surface.

# 5. Geochemistry of Igneous rocks

## *I. Incompatible vs. Compatible Trace Elements*

*A- Incompatible elements:* Elements that are too large and/or too highly charged to fit easily into common rock-forming minerals that crystallize from melts. These elements become concentrated in melts.

*1. Large-ion lithophile elements (LILE's):* Ionic Potential  $> 0.2$ , Incompatible owing to large size (e.g.,  $\text{Rb}^+$ ,  $\text{Cs}^+$ ,  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{K}^+$ ).

*2. High-field strength elements (HFSE's):* Ionic Potential  $< 0.2$ , Incompatible owing to high charge (e.g.,  $\text{Zr}^{4+}$ ,  $\text{Hf}^{4+}$ ,  $\text{Ta}^{4+}$ ,  $\text{Nb}^{5+}$ ,  $\text{Th}^{4+}$ ,  $\text{U}^{4+}$ ,  $\text{Mo}^{6+}$ ,  $\text{W}^{6+}$ , etc.).

*B. Compatible elements:* Elements that fit easily into rock-forming minerals, and may in fact be preferred, e.g., Cr, V, Ni, Co, Ti, etc.

## *II. Trace Elements:*

### *Three Types of Trace-Element Substitution:*

*1. Camouflage:* Occurs when the minor element has the same charge and similar ionic radius as the major element (same ionic potential; no preference.  $\text{Zr}^{4+}$ ;  $\text{Hf}^{4+}$   
Hf usually does not form its own mineral; it is camouflaged in zircon ( $\text{ZrSiO}_4$ ).



*2. Capture:* Occurs when a minor element enters a crystal preferentially to the major element because it has a higher ionic potential than the major element. For example, K-feldspar captures  $\text{Ba}^{2+}$ ; or  $\text{Sr}^{2+}$  in place of  $\text{K}^+$ . Requires coupled substitution to balance charge:  $\text{K}^+ + \text{Si}^{4+} \leftrightarrow \text{Sr}^{2+} (\text{Ba}^{2+}) + \text{Al}^{3+}$ .

*3. Admission:* Involves entry of a foreign ion with an ionic potential less than that of the major ion. Example  $\text{Rb}^+$  for  $\text{K}^+$  in K-feldspar.