GEO 190

ORIGIN of DIAMONDS FROM ULTRA-HIGH PRESSURE TERRANES

SPRING 2007

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COURSE INCLUDES:

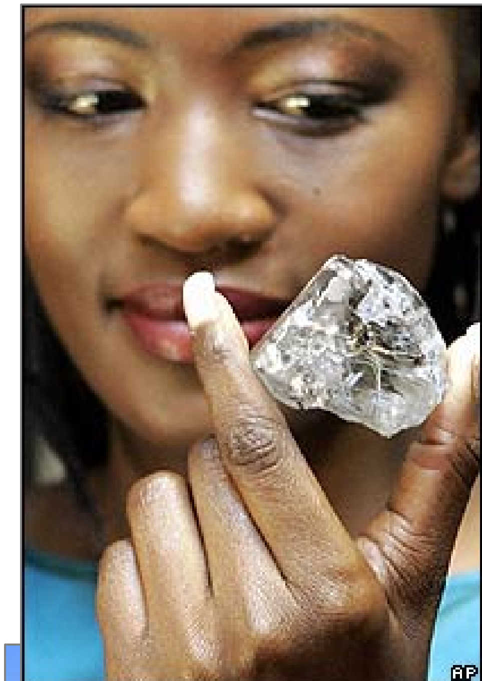
- LECTURES on the theories of diamond formations, their geological localities; scientific and industrial significance
- LABARATORY RESEARCH PROJECTS will be designed individually according to the students interests. They will include: search of microdiamonds in thin sections, image preparations, diamonds studies with an optic microscope in transmitted and reflected lights; minerals associated with diamonds; diamond synthesis in multianvil apparatus at high pressures and high temperatures.

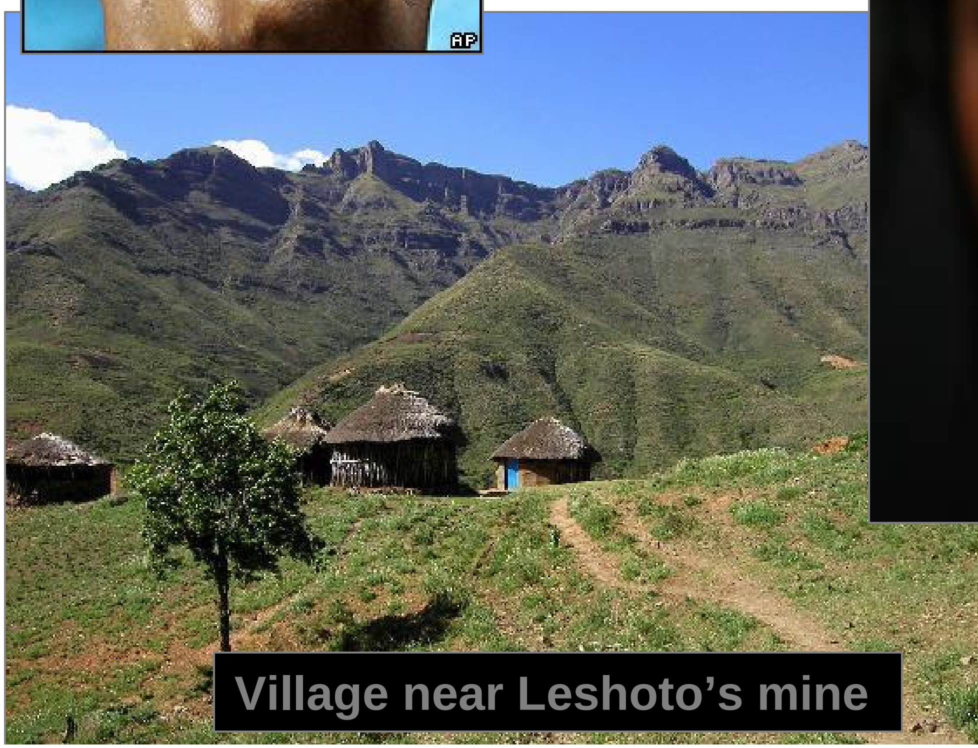
LECTURE 1

DIAMONDS:

INTRODUCTION

Diamond is a subject of admiration as a gemstone & it is a unique technological material due to its extraordinary hardness, transparency & high thermal conductivity. It also a perfect container for inclusions to study the Earth's interior.





Village near Leshoto's mine

603 carat Diamond was found in August 2006 in Leshoto, S. Africa

CARBON IN NATURE

- Carbon exists free in nature and has been known since prehistoric time.
- **Origin:** Latin *carbo*, German *Kohlenstoff*, French *carbone*: coal or charcoal
- **Isotopes:** There are seven natural isotopes of carbon. In 1961 the International Union of Pure and Applied Chemistry adopted the isotope carbon-12 as the basis for atomic weights.
- **Occurrences:**
- Carbon is found free in nature in four allotropic forms: amorphous, graphite, diamond and lonsdleylite.

Carbon place in periodic table

Periodic Table of Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	VII	VII	IB	IB	IIIA	IVA	VA	VIA	VIIA	0
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110								

* Lanthanide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Legend - click to find out more...

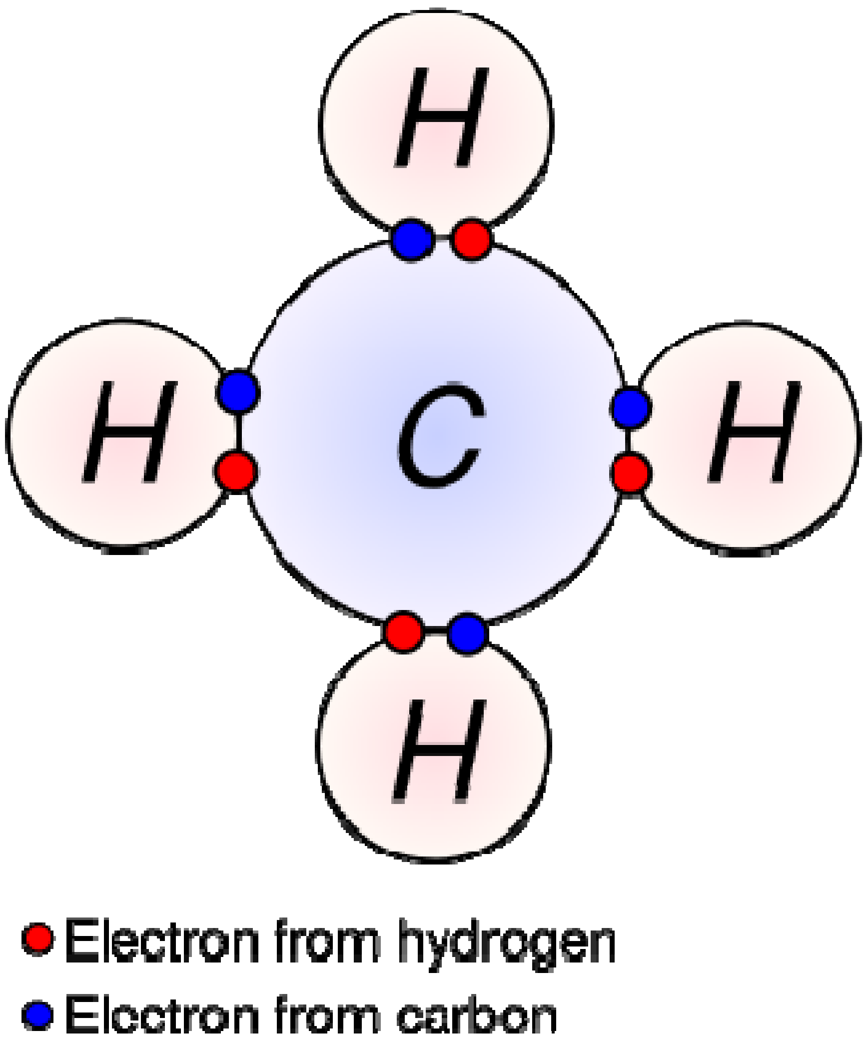
H - gas
Li - solid
Br - liquid
Tc - synthetic

- Non-Metals
- Transition Metals
- Rare Earth Metals
- Halogens
- Alkali Metals
- Alkali Earth Metals
- Other Metals
- Inert Elements

CHEMISTRY OF CARBON

- Virtually all carbon on Earth comes from the stars.
- A neutral carbon atom has 6 protons and 6 neutrons in its nucleus, balanced by 6 electrons.
- The electron shell configuration of carbon is 1s22s22p2.
- Carbon has a valence of 4, since 4 electrons can be accepted to fill the 2p orbital.
- Diamond is made up of repeating units of carbon atoms joined to four other carbon atoms via the strongest chemical linkage, covalent bonds.

COVALENT BONDS



A chemical link between two atoms in which electrons are shared between them.

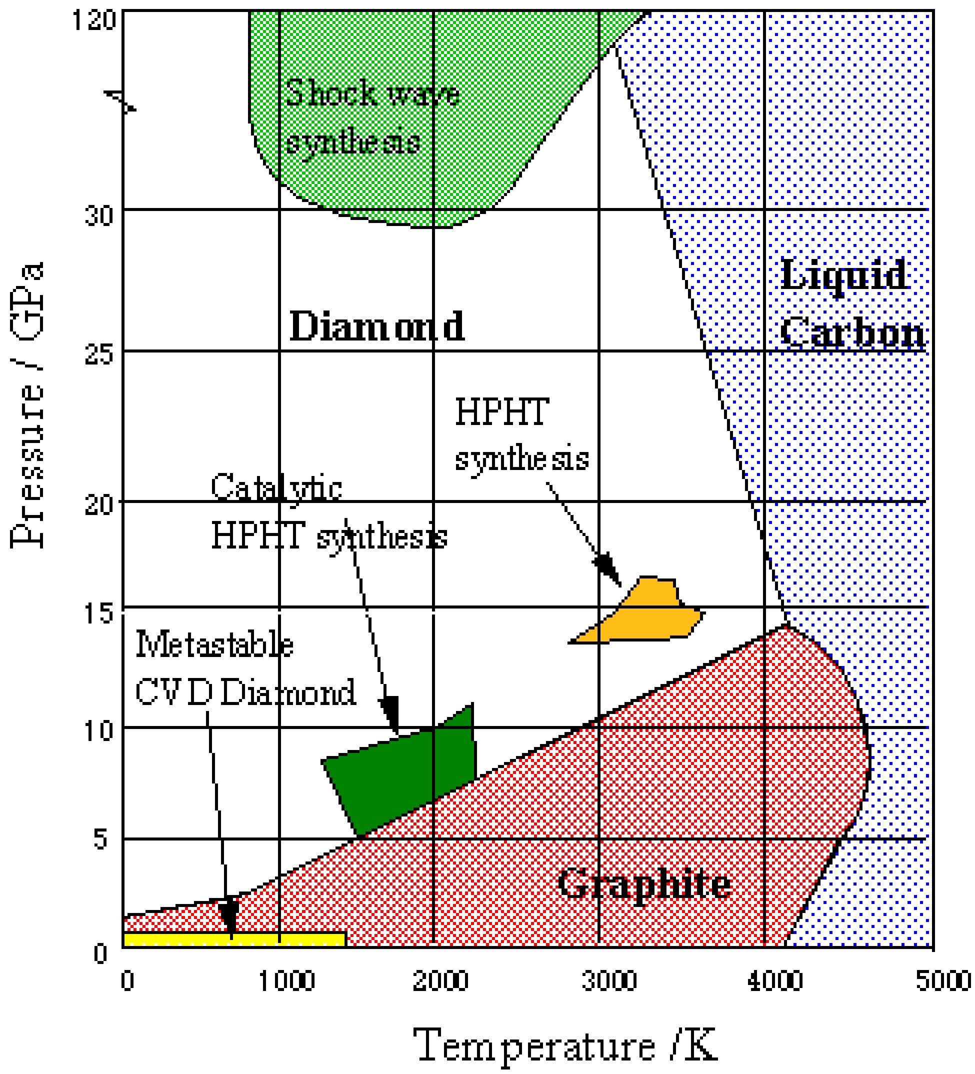
CARBON: DIAMOND

1. Diamond has been prized for centuries as a gemstone of exceptional brilliance and luster. But to a scientist diamond is interesting for its range of exceptional and extreme properties.

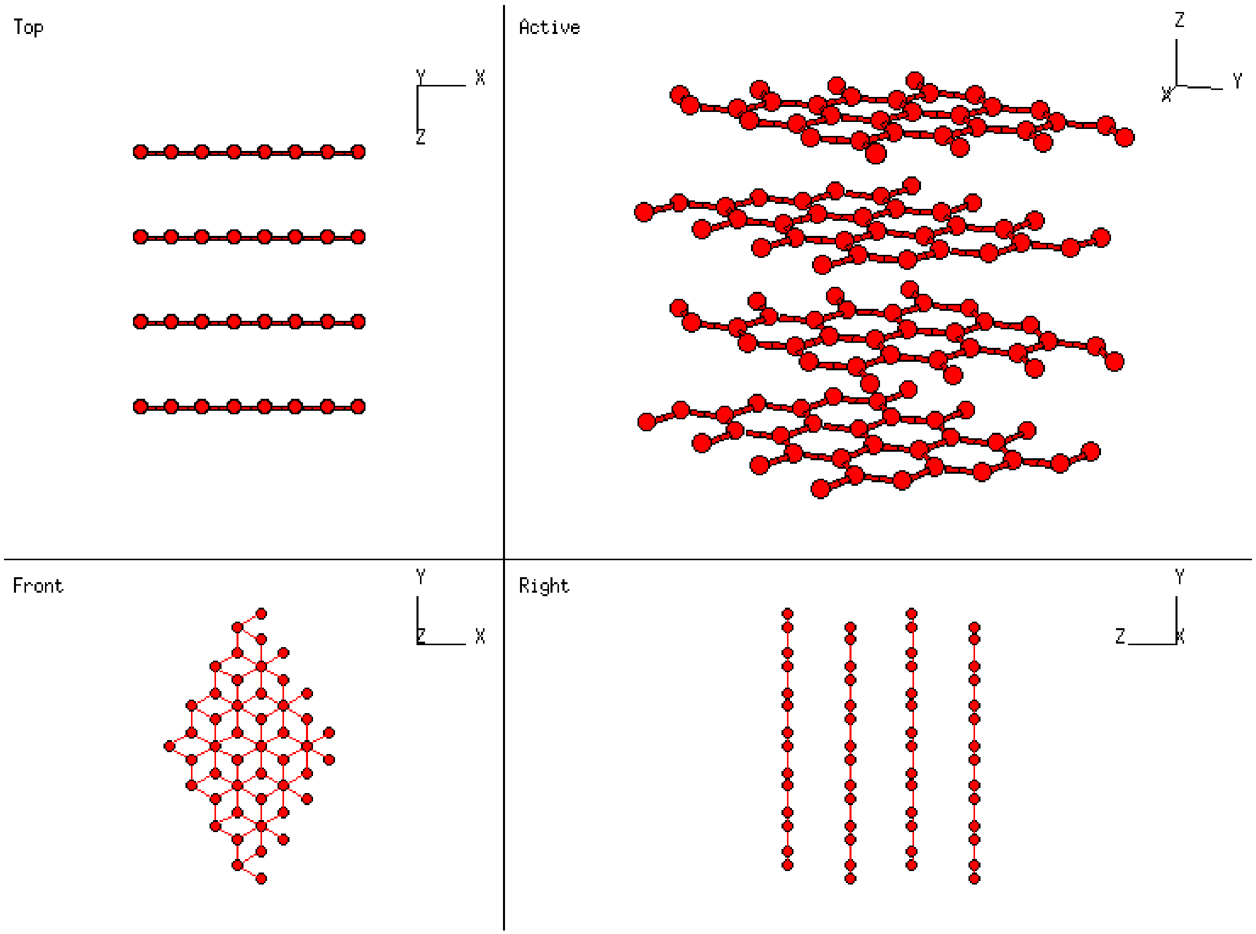
2. When compared to almost any other material, diamond almost always comes out on top.

3. As well as being the hardest known material, it is also the least compressible, and the stiffest material, the best thermal conductor with an extremely low thermal expansion, chemically inert to most acids and alkalis, transparent from the deep uv through the visible to the far infrared.

PHASE DIAGRAM OF CARBON



Graphite structure seen from several perspectives



Graphite has hexagonal symmetry

John A. Jaszczak specimens

Covalent Network

These are giant molecular lattice structures. This implies that strong covalent bonding holds their atoms together in a highly regular extended network. The bonding between the atoms goes on and on in three dimensions.

Melting requires the separation of the species comprising the solid state, and boiling the separation of the species comprising the liquid state. Because of the large amount of energy needed to break huge numbers of covalent bonds, all **giant covalent network structures** have high melting points and boiling points and are insoluble in water.

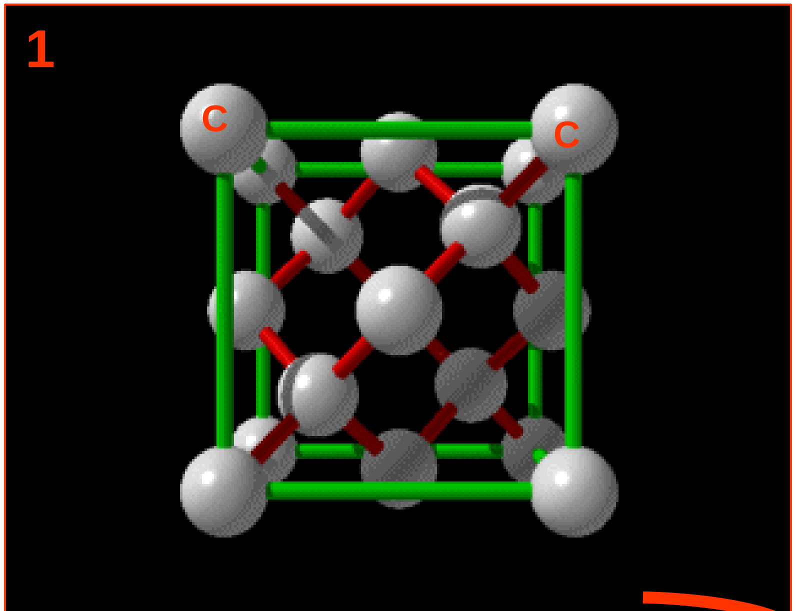
In diamond: a carbon atom with covalent bonds towards the four corners of a tetrahedron

In **graphite** each carbon atom is covalently bonded to three others in the same plane. The bond angle is 120°, and so the carbon atoms can form six-membered rings that link up to form planes or flat sheets of carbon atoms.

DIAMOND: STRUCTURE

- Each carbon atom is in a rigid tetrahedral network where it is equidistant from its neighboring carbon atoms. The structural unit of diamond consists of 8 atoms, fundamentally arranged in a cube.
- This network is very stable and rigid, which is why diamonds are so very hard and have a high melting point (~3600^{o}C).

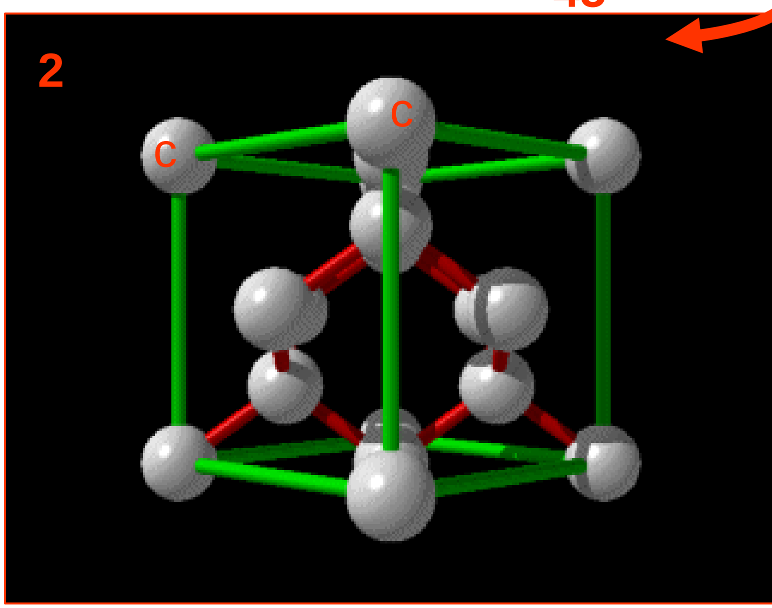
DIAMOND STRUCTURE



One unit cell of diamond structure

1. In the diamond structure the atoms are connected by covalent bonds, with each carbon atom bonded to four others in a tetrahedral geometry. In essence, a sample of diamond is one large molecule.

45º



2. This illustration shows the previous model rotated through an angle of 45 degrees. The open space in the middle is a vacant octahedral hole.

Diamond from Congo ($15,000)