

科目名稱：地球物質 (礦物部分共 50 分)

一、簡答題：

下列是摘自礦物學課本對 *Staurolite* 之描述性資料，請在詳細閱讀後按照題號簡單且完整的回答本題的 10 個小題。(注意：除專有名詞可寫英文外，照抄英文得零分)【共 20 分】

STAUROLITE — $\text{Fe}_{2-4}\text{Al}_8\text{Si}_8\text{O}_{48}\text{H}_{2-4}$

Crystallography. Monoclinic; $2/m$ with $\beta = 90.0-90.45^\circ$ (pseudo-orthorhombic). Prismatic crystals with common forms {110}, {010}, {001}, and {101} (Fig. 1a). Cruciform twins common, of two types: (1) with twin plane {031} in which the two individuals cross at nearly 90° (Fig. 1b); (2) with twin plane {231} in which they cross at nearly 60° (Fig. 1c). In some cases, both types are combined in one twin group. Usually in crystals; rarely massive.

$C2/m$; $a = 7.83$, $b = 16.62$, $c = 5.65 \text{ \AA}$; $\beta = 90.0-90.45^\circ$; $Z = 2$. d_s : 3.01(8), 2.38(10), 1.974(9), 1.516(5), 1.396(10).

Physical Properties. H $7-7\frac{1}{2}$. G 3.65-3.75. Luster resinous to vitreous when fresh; dull when altered or impure. Color red-brown to brown. Translucent. Optics: (+), $\alpha = 1.739-1.747$, $\beta = 1.745-1.753$, $\gamma = 1.752-1.761$; $2V = 82^\circ-88^\circ$; $X = b$ (colorless), $Y = a$ (pale yellow), $Z = c$ (deep yellow); $r > v$.

Composition and Structure. FeO 16.9, Al_2O_3 53.9, SiO_2 28.2, H_2O 1.6% for the pure $\text{Fe}_2\text{-H}_2$ end member. Natural staurolites show a restricted compositional range; however, Zn, Li, Co, Mg, Al and vacancies replace Fe^{2+} up to a few percent, and minor Cr and Ni can be present. Hydrogen content varies from $\sim 2.6-4.2$ apfu (atoms per formula unit), primarily as a function of P and T ; high P staurolite contains more H, high T contains less H. Mg-rich staurolite is known from ultra-high P metamorphic rocks. Mg, Co, Zn end members have been synthesized. Common substitutions include: $2\text{H}^+ \rightleftharpoons \text{R}^{2+}$, $\text{R}^{2+} \rightleftharpoons \text{Fe}^{2+}$, $3\text{Li} + \text{Al}^{3+} \rightleftharpoons 3\text{R}^{2+}$, where R is a divalent cation. The structure has been described to consist of layers of kyanite with $8 \text{ Al}_2\text{SiO}_5$ composition (AlO_6 octahedra in chains parallel to the c axis) alternating with layers of Fe-Al-O-OH along {010}, although the oxide layer is more complicated. Chains of edge-sharing Al octahedra (rutile-like) extend along {001}. Fe in tetrahedral coordination shares vertices with adjacent octahedra and assumes a zig-zag pattern on either side of the chain. Hydrogen is bonded to one O of the Al octahedron; when H is present, Al is typically absent in that octahedron. This leads to order in the structure. Si occupies isolated tetrahedra. Variation in

β correlates with occupancy of Al octahedra and order/disorder; monoclinic at room T , probably orthorhombic ($C2mm$) at high T .

Diagnostic Features. Recognized by its characteristic crystals and twins. Distinguished from andalusite by its obtuse prism and color.

Occurrence. Staurolite is formed during medium-grade metamorphism of aluminum-rich rocks and is found in schists typically associated with pyralispite garnet, muscovite, and biotite. It may grow on kyanite in parallel orientation. Staurolite forms from chloritoid at lower-grades of metamorphism and breaks down to sillimanite and garnet at higher grades. Because of its limited P - T stability, it is commonly used as an index mineral for medium-grade aluminous metamorphic rocks.

Notable localities are Monte Campione, Switzerland, and in large twin crystals in Brittany, France; in Scotland and near Taos, New Mexico. Further United States localities are in northwest Maine, New Hampshire, North Carolina, Georgia, Tennessee, Virginia, New Mexico, and Montana.

Use. The right angle twins are sold as amulets under the name "fairy stone," but most of the crosses offered for sale are imitations carved from a fine-grained rock and dyed, or are molded plastic.

Name. Derived from the Greek word *stauros* meaning cross, in allusion to its cruciform twins.

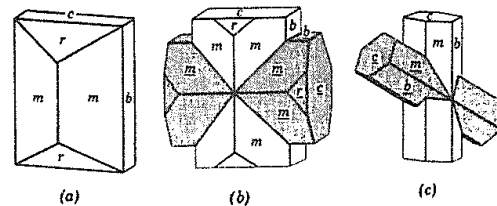


FIG. 1 Staurolite.

1. *Staurolite* 的中文名稱是什麼？屬於哪一個晶系？
2. *Staurolite* 屬於哪個點群？哪個空間群？
3. *Staurolite* 的比重是多少？硬度是多少？
4. *Staurolite* 含有不等量的氫，當生成溫度越高時，所含的氫會越多還是越少？當氫與氧鍵結時，此氧所屬八面體的哪一種金屬離子常會空缺？
5. *Staurolite* 是什麼顏色？一個晶胞中含有多少個氧原子？
6. *Staurolite* 的折射率最高可達到多少？最強 X 光繞射發生在哪兩個晶面間距？(答案應

附單位；單位錯誤得 0 分)

7. *Staurolite* 有什麼明顯鑑定特徵？與紅柱石要如何區分？
8. Fig. 1(a)的 *Staurolite* 晶體有幾個晶面？Fig. 1 中可被稱為 *fairy stone* 的是哪一個晶體？
9. *Staurolite* 若經過高度變質作用會分解生成哪兩種礦物？富鋁原岩經過中度變質而來的哪種岩石中常生成 *Staurolite*？
10. *Staurolite* 名稱是從哪種文字來的？原文代表什麼意思？

二、以下是自然界岩石中常見的十種礦物：

augite	feldspar	kaolinite	leucite	mica
nepheline	olivine	quartz	talc	tourmaline

其中有三種礦物是火成岩、沉積岩與變質岩等三大岩類中都常出現的造岩礦物，有一種是在沉積岩中特有的常見礦物，另有一種是在變質岩中特有的常見礦物。請排除少數例外或少見的狀況，按照最合理與最可能的情況回答以下兩小題：

1. 列出此五種礦物，即 ① 三大岩類都常出現的是哪三種礦物？② 沉積岩中常出現的是哪一種礦物？③ 變質岩中常出現的是哪一種礦物？【5 分】
2. 上小題中的五種礦物各具有哪些重要礦物性質或特徵？請各列舉兩項。（請注意必須是上一小題回答正確的礦物才算分）【10 分】

三、解釋名詞：【每題 5 分，共 15 分】

1. Bravais lattices
2. Isodesmic
3. Zoning of crystals

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四、簡答題：【每小題 2 分，共 14 分】

❖ Table 1 是某矽鋁質深成岩 R 的 CIPW norm：

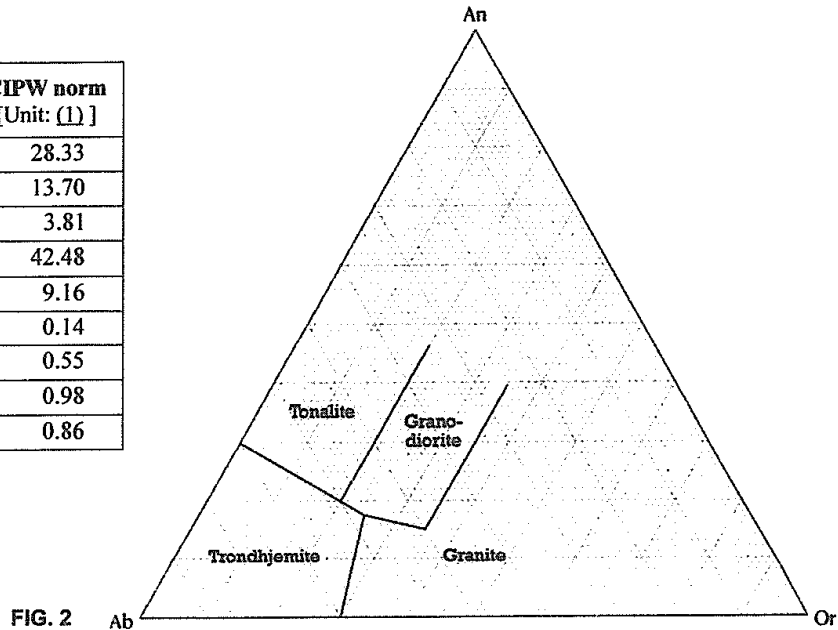
- Table 1 中各礦物組成數值的「單位」為 (1) 。

接次頁

- Fig. 2 是以 CIPW norm 資料建立的岩石分類三角圖。根據 Table 1 的資料，岩石 R 在 Fig. 2 中會被分類為 (2)。

Table 1

Normative minerals	CIPW norm [Unit: (1)]
Quartz	28.33
Anorthite (An)	13.70
Hypersthene	3.81
Albite (Ab)	42.48
Orthoclase (Or)	9.16
Apatite	0.14
Ilmenite	0.55
Corundum	0.98
Magnetite	0.86



- ❖ 砂岩的分類 (Fig. 3) 主要根據岩石中的 (3) 組成是為石英、長石或岩屑的 (4) 比例。
- ❖ 在 Fig. 4 此 Thompson projection 例子中，Grt (石榴子石) 以線段表示，原因在於 (5)。

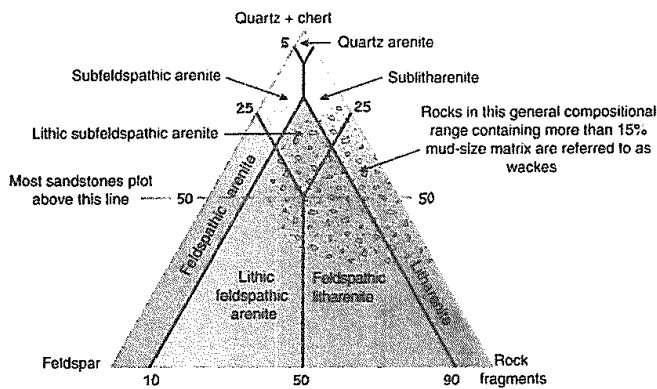


FIG. 3

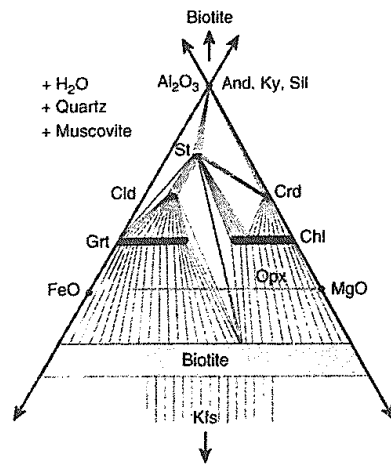
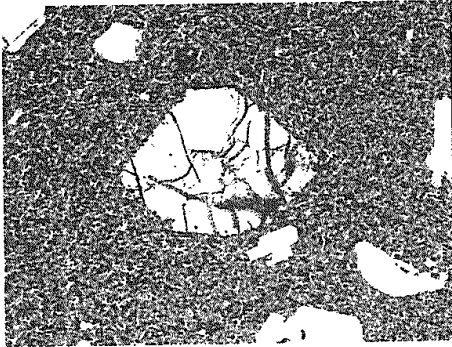


FIG. 4

見背面

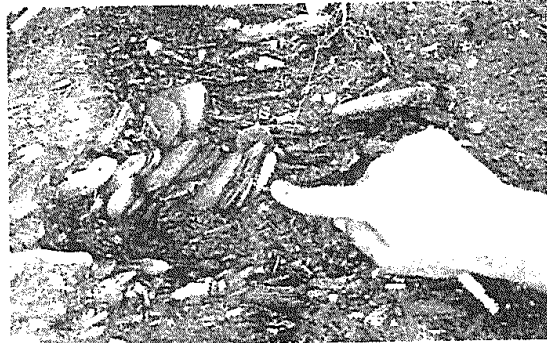
❖ 寫出照片中展現的構造 (structure or texture) 名稱：

(6)



[open nicol; field width: 6 mm]

(7)



五、問答題：【每題 8 分，共 24 分】

1. 台灣島上大多為「高山小河 (small mountain river)」，則使河流碎屑沉積物的物源、形成過程與組成上具有哪些特性？
2. 簡述一般深成岩的 IUGS 分類。
3. 說明海洋地殼玄武岩自於中洋脊形成至隱沒、循環回到地函的過程，會經歷哪些變質作用、形成何種變質岩，並分別列舉它們的標誌礦物。

六、解釋名詞：【每題 4 分，共 12 分】

1. Isograd
2. Pressure solution
3. Sheeted dikes

試題隨卷繳回