

For $(u,v)=(1,2)$ the compound tessellation is the H mode of the hexagonal net, and the multiplicity of the mesh is $n=3$.

For $(u,v)=(1,3)$, $n=7$, no example is known.

For $(u,v)=(1,4)$, $n=13$, an application is found in the twinning of klockmannite. Consider the projection on (001), given by Taylor & Underwood (1960, p. 362, Fig. 3). Starting with the net that has the smallest mesh, tessellation $(u,v)=(4,1)$ defines the true net of crystal I, while tessellation $(u,v)=(1,4)$ gives the net of crystal II. Likewise, starting from the true nets, $(u,v)=(1,4)$ of crystal I and $(u,v)=(4,1)$ of crystal II each gives the same supermesh. For all cells, c has the same value. The twin lattice may be defined either by the supercell or by the subcell of the true cell; the physical significance of the sublattice is obvious.

The same tessellation $(u,v)=(1,4)$ also expresses the net, starting from a subnet, in CuAsSe_2 (Sadanaga, 1962).

A third example is found in benstonite, $\text{Ca}_7\text{Ba}_6(\text{CO}_3)_{13}$, which was described by Lippmann (1962, p. 591, Fig. 1). This species is rhombohedral; its hexagonal cell has $a=18.28$, $c=8.67$ Å. The 'calcite subcell' of benstonite has $a'=a/\sqrt{3}=5.07$, $c'=2c=17.34$ Å (note that calcite has $a=4.990$, $c=17.06$ Å).

For $(u,v)=(1,6)$, $n=31$, the compound tessellation expresses the net of zinkenite, PbSb_2S_4 , from its subnet of metal atoms (Sadanaga & Takeda, 1961, 1964). The hexagonal subcell has $a'=a/\sqrt{31}=3.98$, $c'=c/2=2.16$ Å, with $a=22.17$, $c=4.33$ Å. The angle between the nearest a axes is $8^\circ 57'$. The concept of compound tessellation proved very helpful in deriving the structure of zinkenite.

The structure of koenenite, $4\text{NaCl} \cdot 4(\text{Mg,Ca})\text{Cl}_2 \cdot 5\text{Mg}(\text{OH})_2 \cdot 4\text{Al}(\text{OH})_3$, studied by Lohse, Allmann, Burzlaff & Hellner (1963), consists in an alternation of octahedral layers of two kinds: brucite-like OH double layers, $[\text{Mg}_7\text{Al}_4(\text{OH})_{22}]^{4+}$, and Cl double layers, $[\text{Na}_4(\text{Ca,Mg})_2\text{Cl}_{12}]^{4-}$. The Cl substructure is hexagonal — R : $a_1=4.072$, $c_1=3 \times 10.88=32.64$ Å, and the OH substructure is hexagonal — P : $a_2=3.052$, $c_2=10.88$ Å. The measured angle between a_1 and a_2 is $28.3^\circ \pm 0.1^\circ$. It can be explained by means of tessellations. As was pointed out by Allmann (1965), the compound tessellation $(u,v)=(9,19)$, with $n=271$, of the Cl layer, has a mesh with edge of $4.072/\sqrt{271}=67.03$ Å, which can coincide with a block of 22×22 meshes of the OH layer ($3.052 \times 22=67.14$); and the predicted angle is 28.26° . Allmann also remarks that an angle of 28.35° can be predicted with the compound tessellation $(u,v)=(19,40)$, $n=1201$, of the OH layer, in coincidence with a block of 26×26 meshes of the Cl layer. The large mesh, in this case, would have an edge of 105.67 Å. A third possibility would be to consider a compound tessellation in each kind of layer, and let the meshes coincide.

The regular tessellation $\{6,3\}$ is illustrated by the structure of a graphite sheet.

It is possible to extend the notion of tessellation to quasi-symmetrical cases. The twin lattice in cryolite, Na_3AlF_6 , provides an example. The cell dimensions, determined by

Náray-Szabó & Sasvári (1938), are as follows: $a=5.46$, $b=5.61$, $c=7.80$ kX, $\beta=90^\circ 11'$. The twinning is controlled by the pseudo-symmetry of a double cell, obtained by transformation $110/110/001$. This cell is a pseudo-cube, and in the (001) plane the compound tessellation $\{4,4\} [2\{4,4\}]$ is approximated.

Galena-type substructures in freieslebenite and diaphorite, described by Hellner (1957, 1958), give other examples of this kind of approximate tessellation. Here the cells are orthorhombic, and their edges are multiples of the cell edge a' of the compound tessellation $\{4,4\} [2\{4,4\}]$ of the galena-type substructure: for freieslebenite, $a=2a'$, $b=3a'$; for diaphorite, $a=4a'$, $b=8a'$.

In pectolite $\text{Ca}_2\text{NaHSi}_3\text{O}_9$ (Buerger, 1962) and miargyrite AgSbS_2 (Hofmann, 1938), the subnets resemble $\{3,6\}$'s, but the meshes are parallelograms instead of 120° rhombs.

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The structure of AuMn_3 . By P. GAUNT and A. EDEN, *Department of Physics, The University, Sheffield 10, England*

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Raub, Zwicker & Baur (1953) discovered two compounds in the Au–Mn phase diagram which gave very similar X-ray powder diffraction patterns. The structure of the compound

Au_2Mn was determined by Herpin, Meriel & Meyer (1958) and Hall & Royan (1959). This compound has a spiral magnetic-spin structure and becomes ferromagnetic when a

critical field is applied (Meyer & Tagland, 1956). No definite evidence for magnetic ordering in the compound AuMn_3 has so far been found (Meyer, 1959).

Powder photographs of the material, after annealing at 500°C for 24 hours, were initially indexed on a tetragonal cell with $a=3.328 \text{ \AA}$ and $C=8.539 \text{ \AA}$. This indexing did, however, leave a few weak unexplained lines and density determinations gave 1.48 formula units per unit cell. A larger cell with a increased by a factor of $\sqrt{2}$ allowed all the observed lines to be indexed and gave 2.96 formula units per unit cell. The parameters of the larger cell were: $a=4.706$, $C=8.539 \text{ \AA}$. Most of the observed lines satisfied the face-centred selection rule and lines with $l=3n$ were strong.

The dimensions of the cell and its relationship to Au_2Mn suggested that the structure must be of the form:

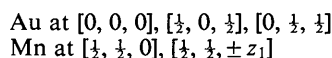


Table 1. $\sin^2 \theta$ values, using copper $K\alpha$ radiation, and observed and calculated structure factors for AuMn_3 assuming $z=\frac{1}{3}$.

Reflexion	$(\sin^2 \theta)_o$	$(\sin^2 \theta)_c$	F_o	F_c
002	0.0324	0.0325	125	153
111	0.0615	0.0616	147	150
200	0.1068	0.1070	364	357
113	0.1267	0.1268	325	347
004	—	0.1302	—	138
210	—	0.1338	—	46
202	0.1393	0.1396	130	138
211	—	0.1419	—	45
220	0.2139	0.2141	304	310
204	0.2368	0.2372	123	127
222	0.2470	0.2467	118	127
115	0.2569	0.2570	137	126
311	0.2761	0.2758	139	125
006	0.2927	0.2929	288	285
313	0.3405	0.3409	290	271
224	—	0.3443	—	120
206	0.3998	0.4000	260	259
400	0.4279	0.4282	256	256
117	0.4529	0.4523	108	113
315	0.4705	0.4711	131	113
226	0.5065	0.5071	221	241
420	0.5349	0.5353	208	237
333	0.5543	0.5550	227	233
404	0.5580	0.5584	—	110
317	0.6654	0.6664	122	105
424	—	0.6655	—	105

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Crystal data (I) for some bile acid derivatives*. By DORITA A. NORTON and BARBARA HANER, *Roswell Park Memorial Institute, Buffalo, New York 14203, U.S.A.*

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Single-crystal data for thirteen bile acid derivatives were collected on a General Electric XRD-5 X-ray diffraction unit equipped with a single-crystal orienter. Reciprocal lattice measurements were made using $\text{Cu } K\alpha$ radiation. Space groups were determined by systematic absences and considerations of optical activity. Densities were determined by flotation and used to calculate the number of molecules

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Mn at $[0, 0, \pm z_2]$, $[\frac{1}{2}, 0, \frac{1}{2} \pm z_2]$, $[0, \frac{1}{2}, \frac{1}{2} \pm z_2]$
where z_1 and z_2 are $\sim \frac{1}{3}$.

This structure would be face centred if the Mn atom at $[\frac{1}{2}, \frac{1}{2}, 0]$ were replaced by gold.

The line intensities were determined by measuring the area of the traces from a Philips powder diffractometer. Anomalies, due to preferred orientation in the closely packed powder, were eliminated by dilution with gum tragacanth. Observed and calculated structure factors for $z_1 = z_2 = \frac{1}{3}$ are shown in Table 1. Where reflexions overlapped, F_o for the strongest line was estimated by subtracting the calculated intensity of the weaker lines from the total observed intensity. Copper radiation was used and all observed spectra up to 313 are recorded in the table. Selected lines at higher angles were measured to fix z within as close limits as possible. From the results it is estimated that assuming $z_1 = z_2$, the best value of z is 0.333 ± 0.007 . The results are not sufficiently precise to make a distinction between z_1 and z_2 possible.

The analysis shows the close similarity between the structures of Au_2Mn and AuMn_3 : if in AuMn_3 the manganese atom at $[\frac{1}{2}, \frac{1}{2}, 0]$ were replaced by gold the structure would be similar to that of Au_2Mn but with manganese at the gold sites and gold at the manganese sites. There are, however, important differences in the environment of the manganese atoms, which would carry the magnetic moment in a magnetically ordered structure. In Au_2Mn the shortest Mn–Mn distance, along $[100]$ and $[010]$ directions, is 3.36 \AA . In AuMn_3 the shortest Mn–Mn distances are the nearest-neighbour distances, in the approximately close-packed (100) and (010) planes, of 2.75 or 2.85 \AA .

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per unit cell. All of the compounds studied were crystallized from solution, and, in most cases, evaporation at room temperature gave a yield of good single crystals. The calculated molecular weights of compounds 2, 5, 8, 11, and 13 show that solvent of crystallization is present and that this solvent is water in 5, 11, and 13. The unusually high discrepancy between the observed and calculated densities of compound 9 probably results from the inaccuracy of the density determination of the crystals, which were small, extremely thin laths. The crystal data are given in Table 1. No further work on these compounds is contemplated.