

Semantic Crystals in Chinese Characters

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There is a chemical analogy for written Chinese: radicals are atoms that join together to form characters that are molecules. The clearest case of this analogy is when one radical is repeated to form a character, much like atoms repeat to form a crystal. A good example of a “crystal character” is 晶 *jīng* ‘bright, glittering; crystalline’ which is written with #72 日 *rì* ‘sun; day’ repeated three times.¹⁾

Which radicals form crystals, and which do not? What are the graphic forms of crystals? Do they have any phonological relationships? What are the semantic principles of these unique crystalline characters?

THE RADICAL-ATOM ANALOGY

Owing to the aptness of the radical as “atom” analogy for Chinese characters, it has been widely used²⁾. Joseph Needham, the pre-eminent historian of Chinese science, gives this explanation:

To the natural scientist approaching the study of Chinese, a helpful analogy is possible with chemical molecules and atoms—the characters may be considered roughly as so many

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- 1) The abbreviation “#” is used to indicate “radical number” in the traditional 214 radicals. This “crystal” *jīng* is used in words for ‘crystal’, e.g., 水晶 *shuǐjīng* ‘crystal; (esp.) rock crystal’ and 結晶 *jiéjīng* ‘crystal, crystallize’. See Tables 8 and 12.
- 2) See the discussion of Tōdō Akiyasu, 藤堂明保, *Kanji gogen jiten* 漢字語源辞典, Gakutōsha, 1965: 39–45.

molecules composed of the various permutations and combinations of a set of 214 atoms. This statement is true because nearly all the phonetics can be broken down into radicals, though this has been a late and artificial process; many had no connection originally with the radicals to which conventionalisation and stylisation have affiliated them. Hence certain characters are so difficult to find that special lists are given at the back of some dictionaries, of words "the radical of which is not obvious". There may be as many as seven "atoms" in one "molecule", and "atoms" may repeat (as if forming a crystal) with as many as three identical ones in one character, e. g., *sen* 森 undergrowth, where the wood radical is repeated thrice.³⁾

Jack Halpern independently rediscovered the "atomic structure of Chinese characters," and says:⁴⁾

... The essence of the scheme is that the formation of Chinese characters can be likened to the way atoms combine to form the more complex molecules of compounds.

For example, the basic element 相 corresponds to a molecule. It can be broken into two meaningful parts 木 (tree) and 目 (eye), each corresponding to an atom. The reasons for such character-forming elements as 木 can be equated to atoms is that, just as splitting a helium atom destroys its basic proper-

3) Joseph Needham, *Science and Civilisation in China*, Vol. 1, Cambridge University Press, 1954: 31-32. #75 木 *mu* 'tree; wood' forms both 林 *lin* 'forest, woods' (from 2 = 'several' trees) and 森 *sen* 'woods; undergrowth; luxuriant vegetation' (from 3 = 'many' trees). See Table 10. Needham says a radical may repeat as many as three times, but there are a few cases of repeating four times, see fn. 10.

4) Jack Halpern, "The Sound of One Land" (part 9), "A Method in the Madness" *PHP* December 1981: 73-80.

ties and leaves only elementary particles, breaking 木 into further pieces will destroy its basic properties and leave only a meaningless jumble of strokes (一 | 八).

On the other hand, elements like 相 are similar to molecules in that they transmit their basic properties of shape, sound, and meaning to the character compounds they form, just like real molecules transmit their physical properties to the chemical compounds they form. The resulting compounds, of course, differ from each other. H₂O (water) and H₂S (hydrogen sulfide) both include hydrogen, but have different properties. Likewise, 想 and 廂 both include 相 but do not share the same meaning.

Halpern has also constructed a fascinating “periodic table” with 308 basic character-forming elements.

Chemical analogies are not only applicable to Chinese characters, and Yuen-Ren Chao discusses a wide variety of chemical analogies for the Chinese language. For example, morphemes as ions capable of binding together into compounds (e. g., 大 *da* ‘large; coarse’ and 意 *yi* ‘idea; mind’ (see fn. 33) forming both 大意 *dayi* (with *yi* in fourth tone) ‘general idea; main point’) and 大意 *dayi* (with *yi* in neutral tone) ‘coarse minded; careless, negligent’; fixed-order morpheme lists as polymers (e. g., 春夏秋冬 *chunxiagiudong* ‘spring, summer, autumn, winter’); substitutions within grammatical frames as isotopes in the periodic table (cf. Halpern’s version above, e. g., 說話 *shuohua* ‘say words’, 聽話 *tinghua* ‘listen to words’, and 談話 *tanhua* ‘talk words’); purely graphic, not spoken, differentiations of meanings as fission (e. g., 文 *wen* ‘writing’ and 紋 *wen* ‘marking’); and blendings of morphemes or syllables as fusion (e. g., 別 *bie* ‘don’t’ from 不要 *buyao* ‘no need; don’t’).⁵⁾

The analogy of radicals as “atoms” and characters as “crystals” is useful for understanding some of the basic semantic principles of written Chinese, but the usefulness is limited.⁶⁾ One limitation is crystal size—the simplest physical crystal (e. g., NaCl, salt) has eight atoms, the simplest character crystal has only two radical repetitions.⁷⁾ Even with the analogical limitations, crystal ideographs are a good subject for analysis because they are the clearest representations of the semantic principles within Chinese characters.

METHOD

This study linguistically analyzes a representative set of ninety-two crystals out of the 20,769 characters in the *Kōkanwa jitan* 広漢和辞典.⁸⁾ This dictionary was chosen to avoid “artificial” dictionary crystals. In analogy with natural or artificial crystals (e. g., a ruby gemstone or a ruby laser); “natural” crystal characters are used in standard, written Chinese; “artificial” crystals are restricted to dictionary Chinese. Taking #212 龍 *long* ‘dragon’ as an example, the *Kōkanwa jiten* lists one crystal: 龍龍 *ta/te* ‘flying dragon; awe’ (see Table 12), and this word is attested. On the other hand, the unabridged *Daikanwa jiten* 大漢和辞典 lists the same “natural” crystal along with two “artificial” ones: 龍龍 *ta* ‘motion

5) Yuen-Ren Chao, “Chemical Analogies in Chinese Grammatical Structure,” in *To Honor Roman Jakobson: Essays on the Occasion of his Seventieth Birthday*, Mouton, 1966: 447–451.

6) “Thus,” as Chao (1966: 447) says, “one would not likely illustrate chemical structures by Chinese grammar, while it is more natural to illustrate the latter by chemical analogies.”

7) Another limitation is semantic arbitrariness—chemical atoms have specific physical qualities, radicals have arbitrary linguistic meanings.

8) Morohashi Tetsuji 諸橋轍次, Kamata Tadashi 鎌田 正, and Yoneyama Toratarō 米山寅太郎, gen'l eds. Taishokan. 1981.

of a dragon' and 龍龍龍 *jie* 'wordy'.⁹⁾ These triple and quadruple 'dragon' crystals are graphic ghosts from previous dictionaries, and unattested in actual usage.

CRYSTALLINE GRAPHICS

Radicals only crystallize in limited graphic combinations. Following the system of chemical notation (e. g., oxygen is represented as O₂), for a given radical X, a double crystal is X₂, a triple crystal X₃, and a quadruple crystal X₄. For example, #24 + *shi* 'ten' has (see Table 9): X₂ of 廿 *nian* 'twenty', X₃ of 卅 *sa* 'thirty', and X₄ of 卌 *xi* 'forty'. Since radicals do not crystallize larger than X₄, there are only the following eight possible permutations of crystals for any given radical.

Table 1 Crystal Combinations

COMBINATION	NUMBER OF RADICALS
X only [no crystal]	141
X, X ₂	36
X, X ₃	12
X, X ₄	1
X, X ₂ , X ₃	20
X, X ₂ , X ₄	—
X, X ₃ , X ₄	—
X, X ₂ , X ₃ , X ₄	4

Only about one-third of all radicals (73 of the 214) form crystals. The most common combinations are for X₂ alone or both X₂ and X₃.¹⁰⁾

Graphic symmetry is an important limiting factor in crystalline

9) Morohashi Tetsuji, gen'l ed. Taishokan. 1960. This joke character with 64 strokes is literally 'wordy' ('strokly?').

10) Only four radicals have X₄ crystals: #9, #29, #30 (see Table 13), and #24 (Table 9). Note that all of these radicals have two or three strokes.

characters. X_2 crystals are written xx or \times ; X_3 written \times or rarely xxx ; and X_4 only written \times . There does not appear to be any systematic difference in meaning among these different symmetries.

Most radicals only occur in one crystalline form, but a few have alternate crystals, such as both an xx and an \times . A non-radical example of graphic alternation is 束 *ci* 'thorn' which crystallizes either horizontally into 棘 *ji* 'thorn bush; bramble' or vertically into 棗 *zao* 'thorn tree; jujube'.

Table 2 Alternate Crystals

RADICAL	CRYSTALS
#36 夕 <i>xi</i> 'evening, dusk'	多 <i>duo</i> 'many, much' 夕 id.
#72 日 <i>ri</i> 'sun; day'	日 <i>xuan</i> 'bright' 昌 <i>chang</i> 'bright; sunlight'
#46 山 <i>shan</i> 'mountain'	山 <i>shen</i> 'two mountains' 出 <i>chu</i> 'go out, depart' [= 出]
#38 女 <i>nu</i> 'woman'	女 <i>nuan</i> 'quarrel, argue' 姁 <i>jiao</i> 'beautiful' [= 姁]
#9 人 <i>ren</i> 'person'	人 <i>yin</i> 'crowd' [= 衆] 人 id.
#30 口 <i>kou</i> 'mouth'	呂 <i>xuan</i> 'call out; noisy' 口 <i>lu</i> 'spine, backbone' [= 呂] 品 <i>pin</i> 'thing; quality' 口 <i>ling</i> 'noisy'

Most alternate crystals are simply graphic variants (marked with [=]). For example, the word *chu* 'depart, go out' is usually written 出, but it can also be written 出 as a crystal with two 'mountains'. Except #9, they all alternate between X_2 forms of xx and \times .¹¹⁾

Crystallizing radicals usually have less than five strokes. Table 3

11) Note that #30's 口 *ling* 'noisy' (cf. Table 13) is a very rare horizontal X_3 form of xxx .

shows the various crystal combinations (from Table 1, excluding the two non-occurring combinations).

Table 3 Combinations by Number of Strokes in Radical

COMBINATION	NUMBER OF STROKES IN RADICAL											
	1	2	3	4	5	6	7	8	9	10	11	12-17
X only	3	15	17	20	12	22	13	6	9	7	4	13
X, X ₂	—	3	9	5	8	8	4	1	1	—	—	1
X, X ₃	1	1	—	3	1	1	1	1	1	1	1	—
X, X ₄	—	—	1	—	—	—	—	—	—	—	—	—
X, X ₂ , X ₃	1	2	3	6	2	2	2	1	—	—	1	—
X, X ₂ , X ₃ , X ₄	—	3	1	—	—	—	—	—	—	—	—	—

There is a general graphic tendency away from unwieldy crystals multiplied from radicals with many strokes.¹²⁾

Most radicals are independent characters, usually pictographs, and cannot be broken down into other radicals. However, there are four exceptional X₂ crystalline repetitions of other radicals.

Table 4 Crystalline Radicals

RADICAL	CRYSTALLINE RADICAL
#1 一 <i>yi</i> 'one'	#7 二 <i>er</i> 'two'
#45 艹 <i>che</i> 'sprout'	#140 艸 <i>cao</i> 'plants'
#60 彳 <i>chi</i> '(left) step'	#144 行 <i>xing</i> 'go, left and right steps'
#21 匕 <i>bi</i> 'spoon; person'	#81 比 <i>bi</i> 'compare; intimate'

In terms of usage as radicals for forming characters, these crystallized radicals—except for #140 (which is more common as a radical than #45)—are less common than their component radicals.¹³⁾

Mirror crystals are a rare graphic form in which a radical is reversed

12) Of the 34 radicals with ten or more strokes, only four (#187, #195, #197, and #212) form crystals.

13) If radicals are "atoms," there is a unique case of a radical with

along the horizontal axis. For example, the graph 北 for *bei* 'north' is written with two 'people' facing back-to-back.¹⁴⁾

Table 5 Mirror Crystals

RADICAL	MIRROR CRYSTAL
#131 臣 <i>chen</i> 'official'	𠄎 <i>kuang</i> 'disobey'
#170 阜 <i>fu</i> 'mound'	𠄎 <i>fu</i> 'space between mounds'
#77 止 <i>zhi</i> 'foot; toe'	止 <i>bo</i> 'spread legs' [= 𠄎]
#26 冂 <i>jie</i> 'seal; mark'	卯 <i>mao</i> 'mortise, trade'

The first mirror crystal shows a bureaucratic universal—the opposition of two 'officials' means 'disobey; be contrary' (see Table 13). Both #170 and #77 have mirrors indicating spatial relationships (see Table 11).

Graphic archaisms are occasionally found among crystalline characters. The original oracle or bronze graphs were crystals; but later graphs (shown in tables with [=]) were written as typical radical-phonetic combinations. For example, #38 女 'woman': 姤 *jiao* 'beautiful' (Table 2) originally had two 'women' but is now written 姤 (with #38 'woman') or 佼 (with #9 'person'); 姦 *jian* 'adultery; wickedness' (Table 13) originally had three 'women' but is now 奸 (also with #38).¹⁵⁾

"subatomic" components resembling an X_3 crystal: #47 川 *chuan* 'river' is similar to 𠄎 *quan* 'small ditch; drain' and 𠄎 *kuai* 'gully; stream'. The size relationship is similar to that for #85 水 *shui* 'water; river', 水水 *zhei* 'twin rivers', and 淼 *miao* 'vast expanse of water' (see Table 9).

- 14) Table 4's #21 匕 'spoon; person' also doubles into #81 比 *bi* 'intimate person; close together; compare' and 化 *hua* 'transform; change'.
- 15) An instance of an archaic crystal being graphically distinguished to clarify meanings is #19 力 *li* 'strength' which has an X_3 of 𠄎 *xie* 'combined strength' (Table 13). This was distinguished between #24 十 'ten' as 協 *xie* 'common, combined' and #61 心 'heart; mind' as 協 *xie*

CRYSTALLINE PHONOLOGY

Crystal characters are semantically motivated ideographs, and pronunciation plays a less important role than in usual radical-phonetic characters. Still, there are three small sets of crystals in which the pronunciations and/or the meanings are almost identical with the radicals.

First, there are crystals that are nearly cognate with their radicals.

Table 6 Similar Pronunciations and Meanings

RADICAL	COGNATE CRYSTAL
#52 丩 <i>yao</i> 'little, tiny'	𠄎 <i>you</i> 'tiny, very small'
#95 玄 <i>xuan</i> 'dark, black'	𠄎 <i>xuan/zi</i> 'dark, black'
#133 至 <i>zhi</i> 'reach, go'	𠄎 <i>zhi/ri</i> 'reach, go'
#142 虫 <i>chong</i> 'bug, insect'	𧈧 <i>chong</i> 'bug, insect'
#31 回 <i>wei</i> 'encircle'	回 <i>hui</i> 'encircle'

These five cognate crystals may seem pleonastic, but were probably developed to distinguish the graphic radicals from their original words.¹⁶⁾

The second phonologically unusual set consists of crystals with similar pronunciations with their radicals, but different meanings.

Table 7 Similar Pronunciations and Different Meanings

RADICAL	CRYSTAL
#39 子 <i>zi</i> 'child'	孖 <i>zi</i> 'twins'
#46 山 <i>shan</i> 'mountain'	屾 <i>shen</i> 'two mountains'
#29 又 <i>you</i> 'right hand'	𠄎 <i>you</i> 'friend' [=友]
#170 阜 <i>fu</i> 'mound'	𠄎 <i>fu</i> 'space between mounds'
#195 魚 <i>yu</i> 'fish'	𩺰 <i>yu</i> 'fish in a row'
#64 手 <i>shou</i> 'hand'	𠄎 <i>shou</i> 'pickpocket'
#100 生 <i>sheng</i> 'produce'	𠄎 <i>sheng/shen</i> 'many'

The phonetic similarities in these crystals do not seem to have any semantic

'coerce, intimidate'.

16) The 'bug, insect' radical, #142 虫 *chong* (or *hui* 'snake'), has both an

significance.¹⁷⁾

The third set of crystals is the reverse of the second.

Table 8 Similar Meanings and Different Pronunciations

RADICAL	CRYSTAL
#89 𠄎 <i>yao</i> 'crisscross'	𠄎 <i>li</i> 'cross, join'
#120 糸 <i>mi</i> 'silk'	絲 <i>si</i> 'silk (floss)'
#155 赤 <i>chi</i> 'red; bare; fire'	赫 <i>he</i> 'red; fire, bright'
#72 日 <i>ri</i> 'sun; day'	𠄎 <i>xuan</i> 'bright'
	昌 <i>chang</i> 'bright; sunlight'
	晶 <i>jing</i> 'bright; light'

These crystals in Table 8 are nearly synonymous with their radicals, but the pronunciation variations would indicate that they were formed to write different words.¹⁸⁾

Most crystalline characters can function alone as independent morphemes, but two are restricted to binomes. These morphologically dependent crystallizations are: 𠄎 *shou* (Table 7, from #64 手 *shou* 'hand') which only occurs in 扒 𠄎 *bashou* 'pickpocket', and 𠄎 *bi* (Table 14, from #154 貝 *bei* 'cowry') which only occurs in 𠄎 𠄎 *bibi* 'exertion; effort'.

CRYSTALLINE SEMANTICS

Crystal characters are essentially semantic constructions; they repeat

interchangeable X_3 蟲, and a synonymous X_2 虫 *kun* 'bug; insect'. See Carr, "Why Did **Djōng* 蟲 Change from 'Animal' to 'Wug'?" *Computational Analyses of Asian and African Languages* 21: 7-14, 1983.

17) These crystals in Table 7 have a variety of semantic bases—#39 and #46 are numerical (Table 9), #100 expresses abundance (Table 10), #170 and #195 are positional (Table 11), and #29 and #64 are interactional (Table 13).

18) Note that all three crystals for #72 share the sense of 'bright' (see Table 12).

a radical in order to represent some related meaning. Two general semantic principles are evident within crystals. A crystal can indicate either some function or some association of the radical's basic meaning. Both types are seen for #39 子 *zi* 'child'—the basic sense doubled into 孖 *zi* 'twins' ('two children', Table 7 and 9), and an associated sense in 孑 *jian* 'weak; gentle' ('child' metaphorically as 'weak', Table 12). For the former case where the basic sense of the radical is maintained, crystals express numbers, abundance, and position (Tables 9–11). For the latter case where the basic sense is altered, crystals express semantic extension and interaction (Tables 12–13).

The most semantically transparent type of crystal is numerical—for a number n , $X_n = 'n \times X'$. This is straightforward semantic multiplication. A non-radical example is 百 *bai/bo* '100' and 百 *bi* '200'.

Table 9 Numerical Crystals

RADICAL	CRYSTAL
#1 一 <i>yi</i> 'one'	二 <i>er</i> 'two' [= #7] 三 <i>san</i> 'three'
#7 二 <i>er</i> 'two'	四 <i>si</i> 'four' [= 四]
#24 十 <i>shi</i> 'ten'	廿 <i>nian</i> 'twenty' [= 廿] 卅 <i>sa</i> 'thirty' 卌 <i>xi</i> 'forty'
#46 山 <i>shan</i> 'mountain'	岫 <i>shen</i> 'two mountains'
#85 水 <i>shui</i> 'water; river'	水 <i>zhei</i> 'twin rivers'
#96 玉 <i>yu</i> 'jade'	珽 <i>jue</i> 'pair of matching jades'
#69 斤 <i>jin</i> 'axe; catty'	斤斤 <i>yin</i> 'double/pair of axe/s'
#172 隹 <i>zhui</i> 'small bird'	隹 <i>chou</i> 'pair/brace of birds'
#152 豕 <i>shi</i> 'pig'	豕 <i>bin</i> 'pair of pigs'
#39 子 <i>zi</i> 'child'	孖 <i>zi</i> 'twins'

The first three radicals in Table 9 are numbers, and their crystals are direct multiplications. The other numerical crystals are X_2 's indicating

some type of 'pairing/doubling'.¹⁹⁾ The particular meanings of the 'pairs' are readily apparent.

Many crystals mean 'many/much' of their radicals. The most common Chinese word for 'many; much' is the first crystal below.²⁰⁾

Table 10 Abundance Crystals

RADICAL	CRYSTAL
#36 夕 <i>xi</i> 'evening, dusk'	多 <i>duo</i> 'many, much'
#172 隹 <i>zhui</i> 'small bird'	隹隹 <i>za</i> 'flock of birds'
#187 馬 <i>ma</i> 'horse'	馬馬 <i>biao</i> 'herd of horses'
#112 石 <i>shi</i> 'rock, stone'	磊 <i>lei</i> 'pile/heap of stones'
#32 土 <i>tu</i> 'dirt, earth'	土土 <i>yao</i> 'high (pile of dirt)'
#167 金 <i>jin</i> 'gold; metal'	鑫 <i>xin</i> 'rich'
#182 風 <i>feng</i> 'wind'	風風 <i>xiu</i> 'windy, stormy'
#82 毛 <i>mao</i> 'hair, fur'	毳 <i>cui</i> 'dense-haired, shaggy'
#85 水 <i>shui</i> 'water; river'	淼 <i>miao</i> 'vast expanse of water'
#100 生 <i>sheng</i> 'birth, growth'	牲 <i>shen/sheng</i> 'many'
#45 艸 <i>che</i> 'sprout'	艸 <i>cao</i> 'plants' [= #140]
#140 艸 <i>cao</i> 'plant'	艸 <i>mang</i> 'luxuriant foliage'
#75 木 <i>mu</i> 'tree; wood'	林 <i>lin</i> 'thicket, forest'
	森 <i>sen</i> 'forest, woods'
#9 人 <i>ren</i> 'person'	人人 <i>yin</i> 'crowd' [= 衆]

Most of these 'abundance' crystals directly result from 'many/much' of their radicals. There is a similarity in the X₃ crystals of #9, #172, and #189 which mean 'crowd; many people', 'flock; many birds', and 'herd, many horses'.²¹⁾ One of the few abstract meanings for an abundance

19) While 'two mountains' can stand together (Tables 2 and 7), 'two rivers' usually flow together, thus the crystal means 'twin rivers; tributaries'.

20) Cf. Table 2. The traditional explanation, based on bronze graphs, was that this graph repeated #36 夕 'evening', expressing the idea that 'evenings' (and days) repeat 'many' times. The modern explanation, based on oracle graphs, is that it originally showed #130 肉 'meat', indicating 'much; plenty'.

crystal is 'rich' from an 'abundance' of #167 'gold'.

Spatial or positional crystals express a meaning of 'side by side' or 'in a row/line'.

Table 11 Positional Crystals

RADICAL	CRYSTAL
#115 禾 <i>he</i> 'growing grain'	秝 <i>li</i> 'grain planted in a row'
#195 魚 <i>yu</i> 'fish'	鯨 <i>yu</i> 'fish swimming in a row'
#117 立 <i>li</i> 'stand'	竝 <i>bing</i> 'side by side' [= 並]
#154 貝 <i>bei</i> 'cowry'	眼 <i>ying</i> 'necklace'
#102 田 <i>tian</i> 'field'	𠩺 <i>jiang</i> 'two fields together'
	𠩻 <i>lei</i> 'fields divided by dykes'
#170 阜 <i>fu</i> 'mound'	𠩼 <i>fu</i> 'space between mounds'

Most positional crystals are X_2 forms meaning of 'two X's in a row'—except for #154 'cowry' which means 'many' in a 'necklace' (cf. Table 14). The 'field' radical #102 has both a typical X_2 meaning 'two fields together', and the only positional X_3 crystal meaning 'fields divided by dykes'.²²⁾

The linguistically universal process of semantic extension is used in the formation of crystals. These crystals extend the meaning of a radical into a new semantic realm. Compared with the more semantically "literal" types of crystals above (Tables 9–11), extensional crystals (Tables 12–13)

21) See Table 9. All three have interesting extensions. Both 𠩺 *za* 'flock of birds' and 𠩻 *biao* 'herd of horses' are "put up in a 'tree'" (#75)— 集 *ji* 'gather, assemble' and 榮 *sen* 'flourish, prosper'. The three 'people' in 𠤎 or 𠤏 *yin* 'crowd of people' compares with 𠤐 (or 衆) *zhong* 'crowd of people' written with the addition of an 'eye'. The crystals of both #112 and #32 have similar meanings; cf. #28 厶 *si* 'self' which had an archaic X_2 of 厶 *lei* 'pile up earth (esp. for walls)', and #32's 𠩺 *yao* 'high (pile of dirt)' (cf. the X_2 of 圭 *gui* 'ceremonial jade baton').

22) This X_3 𠩻 *lei* 'fields divided by dykes' had an archaic X_4 𠩼 which was probably graphically clearer, but had more strokes.

are more “figurative” in meaning. For example, 弓 *jiang*, the double crystal of #57 弓 *gong* ‘bow’, metaphorically means ‘strong’ (‘bows’ > ‘strong’), not literally ‘two bows’.²³⁾

Table 12 Extensional Crystals

RADICAL	CRYSTAL
#195 魚 <i>yu</i> ‘fish’	魚 <i>xian</i> ‘fresh, new’ [= 鮮]
#123 羊 <i>yang</i> ‘sheep’	羊 <i>shan</i> ‘frowzy, rank smell’
#198 鹿 <i>lu</i> ‘deer’	鹿 <i>cu</i> ‘separated, coarse’ [= 粗]
#93 牛 <i>niu</i> ‘ox, cow’	犇 <i>ben</i> ‘frightened herd of cows’
#94 犬 <i>quan</i> ‘dog’	犬 <i>yin</i> ‘bite, gnaw’
	犬 <i>biao</i> ‘running pack of dogs’
#212 龍 <i>long</i> ‘dragon’	龍 <i>ta/te</i> ‘flying dragon’
#86 火 <i>huo</i> ‘fire’	炎 <i>yan</i> ‘burn, flame, blaze’
	火 <i>yan</i> ‘spark, flame, blaze’
#72 日 <i>ri</i> ‘sun; day’	日 <i>xuan</i> ‘bright’
	昌 <i>chang</i> ‘bright, sunlight’
	晶 <i>jing</i> ‘bright, light’
#106 白 <i>bai/bo</i> ‘white’	晶 <i>xiao/jiao</i> ‘white, bright’
#159 車 <i>che</i> ‘cart, car’	轟 <i>hong</i> ‘noisy (traffic)’
#39 子 <i>zi</i> ‘child’	孑 <i>jian</i> ‘weak, gentle’
#97 瓜 <i>gua</i> ‘melon’	瓜 <i>yu</i> ‘weak, flexible’
#57 弓 <i>gong</i> ‘bow; arch’	弓 <i>jiang</i> ‘strong’

The first six extensional crystals indicate some characteristic associated with their animal radicals.²⁴⁾ The common idea of ‘bright’ is expressed

23) This ‘strong’ compares with 弱 *ruo* ‘weak’ which has an uncertain graphic signification.

24) #195 ‘fish’ (as a food) into ‘fresh, new’ (because ‘fish’ is best when eaten ‘fresh’, cf. X₂ in Table 11); #123 ‘sheep’ into ‘frowzy’ (because ‘sheep’ can have a ‘rank/frowzy smell’); #198 ‘deer’ into ‘rough; coarse; separated’ (supposedly because a herd of ‘deer’ will ‘separate’ from one another); #93 ‘cow; ox’ into ‘frightened’ (since ‘cows’ ‘frighten’ [are “cowed”] easily); #94 ‘dog’ into an X₂ meaning ‘bite; gnaw, chew’ and an X₃ meaning ‘pack of dogs running’ (both familiar

with X₂ and X₃ crystals of #86 'fire', #72 'day; sun' (cf. Table 8), and #106 'white'. There is a higher degree of arbitrariness in these extensional crystals, and the meanings are not always obvious.²⁵⁾

Table 13 Interactional Crystals

RADICAL	CRYSTAL
#112 石 <i>shi</i> 'stone, rock'	石 <i>lai</i> 'sound of stones hitting'
#62 戈 <i>go</i> 'spear, lance,	戔 <i>can</i> 'fight, injure' [= 殘]
#18 刀 <i>dao</i> 'knife'	刃 <i>bo/bao</i> 'to peel/skin' [= 剥]
	刃 <i>li</i> 'separate; cut up'
#51 干 <i>gan</i> 'shield'	干 <i>jian</i> 'level, even'
#11 入 <i>ru</i> 'enter'	入入 <i>liang</i> 'enter together'
#19 力 <i>li</i> 'strength'	勐 <i>xie</i> 'combine strength'
#48 工 <i>gong</i> 'work, skill'	工工 <i>zhan</i> 'discern; disclose'
#61 心 <i>xin</i> 'heart, mind'	惛 <i>suo</i> 'doubt, suspicion'
#9 人 <i>ren</i> 'person'	人人 <i>cong</i> 'follow, obey' [= 從]
	人人 <i>yu</i> 'plan, contemplate' [= 虞]
#38 女 <i>nu</i> 'woman'	姦 <i>nuan</i> 'quarrel, argue'
	姦 <i>jian</i> 'adultery; wicked'
#131 臣 <i>chen</i> 'official'	詭 <i>kuang</i> 'argue, be contrary'
#28 厶 <i>si</i> 'private; self'	厶厶 <i>lin</i> 'neighbor' [= 隣]
#64 手 <i>shou</i> 'hand'	手手 <i>gong</i> 'hold in hands' [= #55]
#29 又 <i>you</i> 'right hand'	友 <i>you</i> 'friend' [= 友]
	𠂔 <i>zhuo</i> 'join, bind'
#55 扌 <i>gong</i> 'clasp hands'	扌 <i>ju</i> 'give' [= 舉]
#30 口 <i>kou</i>	口口 <i>xuan</i> 'noisy, call out' [= 喧]
	𠂔𠂔 <i>ling</i> 'noisy, many voices'
	𠂔𠂔 <i>ji</i> 'noisy, clamorous'
#149 言 <i>yan</i> 'speak, talk'	諍 <i>jing</i> 'argue' [= 競]
	𠂔𠂔 <i>te</i> 'speak rapidly'
#109 目 <i>mu</i> 'eye'	目目 <i>ju</i> 'stare, look about'
#147 見 <i>jian</i> 'see'	見見 <i>yao</i> 'see together'
#181 頁 <i>ye</i> 'head'	頁頁 <i>tian</i> 'adjust, harmonize'
#128 耳 <i>er</i> 'ear'	耳耳 <i>die</i> 'settle a price'
	聾 <i>nie</i> 'whisper' [= 囁]

canine actions); and #212 'dragon' into 'flying dragon' (since 'dragons' are supposed to 'fly').

25) It is easy to see why #39 'child' has a crystal meaning 'weak', but why

The most common type of crystal is interactional: X_n means some interaction between/among n X 's (see Tōdō 1965: 45–46). The meaning of an extensional crystal (Table 12) comes from property of X —that of an interactional crystal (Table 13) comes from some activity of X 's.²⁶⁾

These twenty-nine interactional crystals display a wide variety of meanings concerning activities, concepts, and relations.²⁷⁾ Many interactive crystals involve radicals for bodily parts and actions. The sexism of ancient China is reflected in the crystals of #9 'person; "man"' with positive meanings of 'follow, obey' and 'plan; contemplate', and the archaic ones of #38 'woman' meaning 'quarrel, argue' and 'adultery, wicked' (cf. Tables 2 and 10).

There are a few miscellaneous crystals which do not fit into any of the above categories.²⁸⁾

Table 14 Miscellaneous Crystals

RADICAL	CRYSTAL
#3 丶 <i>ju</i> 'dot'	丶 <i>yi</i> '(Sanskrit letter) <i>i</i> '
#37 大 <i>da</i> 'big'	大 <i>bi</i> 'compare' [=比]
#74 月 <i>yue</i> 'moon'	朋 <i>suan</i> 'friend'
#113 示 <i>shi</i> 'reveal'	禪 <i>suan</i> 'count' [=算]
#154 貝 <i>bei</i> 'cowry'	轟 <i>bi</i> 'exert'
#160 辛 <i>xin</i> 'acid'	辛 <i>jian</i> 'accuse'

#97 'melon; gourd'? Because 'melon' vines are 'flexible; weak'?

- 26) The $n=2$ or 3 for all these interactional crystals, would it be possible if $n=4$? The word 囂 *xiao* 'clamor, hubbub' is ideographically written with a 'head' surrounded by four 'mouths'.
- 27) #51 'shield' somehow interacts into 'level, even' (allegedly from the practice of putting two shields together to make a balance). These 'peel' and 'cut' crystals of #18 may be extensions (Table 12) rather than interactions, since only one 'knife' is required. Cf. #11's crystal with the 'pair' crystals in Table 9 and with 兩 *liang* 'a pair'. #61 'heart; mind' has a crystal of 'doubt, suspicion' (from having more than one 'mind')

These irregular crystals might be phonetically or graphically motivated, but their semantic indications are not clear.

SUMMARY

About one-third of all radicals form crystals. Crystallizing radicals tend to have few strokes and high saliency. The graphic forms of crystals are usually X_2 or X_3 (rarely X_4). In general, phonological aspects of crystalline characters are less important than graphic or semantic ones.²⁹⁾

The overall semantic distribution among crystal types is as follows.

Table 15 Crystal Types

TABLE	CRYSTAL TYPE	NUMBER
13	Interactional	29
12	Extensional	17
10	Abundance	15
9	Numerical	13
11	Positional	7

The most common crystal is interactional (e. g., 磊 *lai* 'sound of stones hitting together' from 'stones'). There are about half as many crystals that are extensional (e. g., 孺 *ju* 'weak, gentle' from 'child'), abundance (e. g., 磊 *lei* 'pile of stones' from 'stone'), and numerical (e. g., 孖 *zi* 'twins' also from 'child'). Positional crystals are the least common (e. g.,

about something). Two related expressions are 二心 *erxin* (lit. "two minds") 'insincere, disloyal' (perhaps 'half-hearted?') and 多心 *duoxin* (lit. "many minds") 'suspicious; oversensitive'. Cf. having *half a mind*.

28) Some other miscellaneous crystals and graphic variants are mentioned in Tables 4 and 13, and footnotes above.

29) A few crystals (see Tables 6–8) have pronunciations and/or meanings that are nearly identical with their component radicals. These are all exceptions to the rule of crystals being semantically motivated.

禛 *li* 'grain planted in a row' from 'grain').

Crystals often have meanings of 'pair' (usually X_2 's), 'many; much' and 'bright'. The forms of crystals exhibit some regularities of meaning. Interactional and numerical crystals are usually X_2 ; while many extended crystals are X_3 .

For several radicals that form both X_2 and X_3 crystals, the X_2 has a less abstract meaning than the X_3 . Two good examples of this contrast are #149's 言 *jing* 'argue' and 𠄎 *te* 'speak rapidly', and #128's 耳 *die* 'bargain' and 聾 *nie* 'whisper'.³⁰⁾ Does a higher value of n imply a higher level of X_n abstraction?³¹⁾

CONCLUSIONS

This survey of crystal characters is a preliminary step towards analyzing the larger, and linguistically more important, set of ideographs.³²⁾ An intermediate step would be to analyze non-radical crystals; for example, 兔 *tu* 'rabbit' triples into 𪗇 *fu/po* 'quick, rapid' (from the association of 'quick' as a 'rabbit').

Crystal characters are especially suitable for basic analysis because they repeat a single radical. Ideographs are comparatively more complex because they combine two or more different radicals/ideas. For example, #61 心 *xin* 'heart; mind' has a semantically transparent crystal 𢀇 *suo* 'doubt, suspicion' (see fn. 27). This 'heart/mind' radical combines with the non-crystallizing #189 音 *yin* 'sound; voice' to form the ideograph

30) Two animal examples are #94's 𪗇 *yin* 'bite; gnaw' and 𪗇 *biao* 'pack of dogs running', and #172's 𪗇 *chou* 'pair of birds' and 𪗇 *za* 'flock of birds'.

31) The answer would, of course, depend upon what "abstraction" means.

32) Crystals account for less than one percent of characters, there are many times more ideographs.

意 *yi* 'meaning; idea; thought'—an 'idea' being a sort of 'voice in the mind'.³³⁾

Alfred H. Bloom uses 意 in asking a Whorfian question about ideas of 'idea':

Does the fact that the Chinese lexicon includes words roughly equivalent to the English terms 'suggestion', 'mental perspective', and 'meaning' but has no term directly equivalent to the English word 'idea' imply that English speakers have an idea that Chinese speakers do not share?³⁴⁾

A parallel question is:

Does the fact that written Chinese includes semantically motivated crystals and ideographs, such as 意 and 意, imply that alphabetic languages are semiotically inadequate that alphabetic languages are semiotically inadequate?

Repeated radicals form ideocrystals, combined radicals form ideomolecules. What is the ideochemistry of Chinese?

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- 33) A much later explanation is that we (should?) 'think' before we 'speak'. This ideograph is a phonetic in: 憶 *yi* 'remember, recall', 臆 *yi* 'bosom; heart; opinion', 噫 *yi* 'alas, oh!', and 億 *yi* '100,000; calculate; satisfied'.
- 34) *The Linguistic Shaping of Thought: A Study of the Impact of Language on Thinking in China and the West*, Lawrence Erlbaum, 1981: 1.