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Systemic approach to technological phenomena. A ceramic example in southern Levant (3700-3500 BC)

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Introduction

When studying emergence of technical traditions, the concept of “ technological choices ” raises serious problems. According to this concept, technical actions are not related “ solely to the physical phenomena that are set in motion by a given technique ” (Lemonnier, 1993 :3) . They are the result of mental processes that are embedded in broader, symbolic system. “ ... A technique appears to us (and to the actors) as a means to achieve a given physical goal by particular (and coherent) material means, whereas in the creative process of innovation, these “ technical ” elements were in fact chosen mostly in accordance with various “ social strategies and meanings. ” (Lemonnier, 1993 :5). In this respect, technical innovation is seen as conform to some physical principles of action on the material world, though basically as a response to non-technological logics. The key process would be a social perception of principles of action on matter. It follows that, for instance, the general invention of stone adzes in many places in the world is interpreted as the result of both various social strategies and a unique social perception of the physical principles of action on raw material (Lemonnier, 1993 :23-24).

In this approach the complex phenomenon of technical innovation is disentangled into elementary factors and one of them is implicitly supposed to act as the trigger. Moreover, the mechanisms which underlay changes in technical systems cannot be specifically understood. As a consequence, the view of technical convergence as a unique social perception of the physical principles on raw material does not explain why some universal perception came into being - was “ actualized ” - at the same moment in many places and why this universal perception took everywhere the same form.

The laws of evolution have been shown to underlay evolution of techniques (Simondon, 1958). These laws are ignored by the “ culturalist ” approach. On the same way the concept of “ adaptive strategies ” is rejected since technical facts are

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considered to be part of a socio-cultural sphere from which they could not be isolated (Dobres and Hoffman, 1994, Pfaffenberg, 1992, Ingold, 1993).

In order to get out this dead end, we propose that technical traditions should better be viewed as a complex process which emerges from the interaction between the different components of the three elements at stake in technical actions : technological knowledge, environment and subject's intention. Technological knowledge comprises knowledge of *chaînes opératoires* for making an object, and cognitive and motor skill. A *chaîne opératoire* is characterized by the logical coherence that links the different steps of the manufacturing process which can be achieved according to different techniques, methods and tools. Cognitive and motor skills correspond to the know-how and the concept involved in the making of an object. Environment relates to the provenance of the raw material and its properties. Subject's intention responds to cultural norms and in this regard to both consumer and producer's demand. It is defined here as the expression of socio-cultural representations.

Each of these three elements present constraints. Technical tradition may be seen as a permanent adjustment between different orders of constraints which may interact. However, it does not mean that traditions only result from constraints. They may play with constraints and consequently same constraints can give different results and different constraints can give same results.

In order to understand how a set of constraints gives birth to a specific tradition, study of technological traditions requires not only an analysis in terms of adjustment to constraints, but also an analysis of the conditions under which they have come into being. These conditions are called here **conditions of actualization**. They correspond to the socio-cultural context into which technological transformations take place.

To illustrate of this systemic and contextual analysis, we propose to examine the ceramic assemblage of a Chalcolithic site (3700 BC-3500 BC) that is located on the east bank of the Jordan Valley, Abu Hamid (Dollfus and Kafafi, 1988). This ceramic assemblage presents both phenomena of technical innovation and differentiation in a highly diversified environment. Therefore, it provides a favorable situation to study how the different technological, environmental and cultural parameters interact in the processes of technical traditions.

Chalcolithic ceramics of Abu Hamid

The Chalcolithic period of southern Levant is characterized by the emergence of big villages, differential occupation of the territory, ritual places, long distance exchange networks. It raises questions about macro-regional organization of the communities. According to the authors, social organization is interpreted either as hierarchical with institutionalized offices of leadership (Levy and Holl, 1988) or, conversely, as "egalitarian" without any social ranking or stratification (Gilead, 1988).

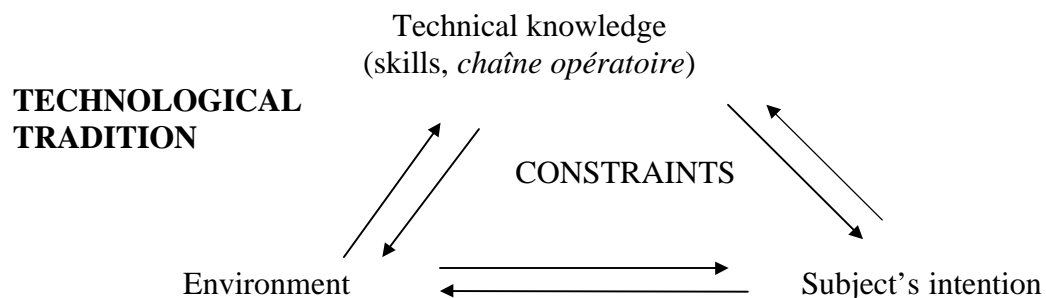
Ceramic assemblages of this period witness a major technical change : the introduction of the wheel for fashioning vessels. This new technique applies to one and only one particular category of pot : the V-shaped bowls. These bowls are found on almost every chalcolithic site of southern Levant. They represent between 40% and 60% of the ceramic production. The rest of the production is composed of coiled vessels. In Abu Hamid, coiled vessels witnesses the emergence of two main sub-traditions characterized by two

chaînes opératoires which differentiate themselves by the clay preparation and finishing process (Roux et Courty, 1998).

The hypothesis is that a systemic analysis of these two technical phenomena - innovation and differentiation - should enable to approach the mechanisms that underlay changes in technical systems. This should help to understand the role played by some elements which in the dynamic of the Chalcolithic communities.

1. Methodology

The methodology followed has consisted, at first, to isolate the three parameters characterizing technical actions - technical knowledge, environment and subject's intention - and to define for each of them the properties of their components in terms of resources and constraints. Our final goal was to emphasize the importance of interaction between the dynamic of technical action and the subject's perception of what the environment can provide in a situation with well defined socio-cultural representations.



Technical knowledge can be interpreted by reference to experimental data. In a previous study we showed how diagnostic surface features and microfibrils enable to distinguish between wheel throwing and wheel fashioning (Courty and Roux, 1995), and also between the different possible wheel fashioning methods. For the latter that corresponds to a combination of coiling and wheel shaping, we showed that an essential question was to define at what stage rotative kinetic energy (RKE) is used for shaping the clay (Roux and Courty, 1998).

Compared to the coiling process, the wheel fashioning process presents the following properties (Roux and Courty, 1998):

- method : similar to the one underlying the coiling process
- technique : introduction of a new source of energy for transforming clay walls : the rotative kinetic energy (RKE)
- tool : a wheel whose speed is not braked by the pressures of hands/fingers when applied on clay walls. The linear speed of a potter's wheel is between 0.5 and 1m/s. The speed is all the more rapid when the pot is small (shaping large pots with the help of RKE requires the wheel to turn more slowly than with small pots).
- time manufacturing : little gain of time compared to the coiling process. The wheel fashioning technique is much less rapid than the wheel throwing technique.

In terms of concept, introducing RKE for fashioning assembled elements represents a major change of physical modalities and therefore a new concept. However, from a methodical point of view, combination of coiling and wheel shaping does not differ from the coiling sequence. Conversely, the skills involved in wheel

shaping are radically different from the ones involved in coiling and long to be mastered (Roux and Corbetta, 1989). In this regard, wheel-fashioning differs from preceding fashioning techniques and may be considered as a major technical breakthrough.

For a differentiation in between coiled vessels, experimental data have enabled us to characterize surface treatments in terms of finishing process. Diagnostic attributes help to distinguish between finishing with fingers or with hard tool, and between presence or absence of a slip.

Determination of the raw materials, their properties and their modification by human actions has been deduced from a comprehensive classification of the clay materials recognized in the chalcolithic ceramic assemblage of Abu Hamid (Roux and Courty, 1997). In this previous study, petrographic and micro-fabric analysis performed under the binocular and the optical microscope led to identify a great variability of clay materials that is expressed by two groups of variables: (1) the properties of the raw material, i.e. the fine mass commonly defined as the clay but in fact dominantly made of clay – particles finer than $2\ \mu\text{m}$ - with variable amount of silt and fine sands; (2) the properties of the coarse inclusions, generally designated as the temper although this term should be restricted to the coarse particles which have been intentionally added to the clay.

Properties of the fine mass and coarse inclusions of the ceramics were compared with a reference data base of surficial deposits and soils which were available in the Jordan valley during the Chalcolithic period. The latter was established from a detailed soil stratigraphic survey that was aimed to reconstruct the evolution of the Jordan valley palaeogeography at a micro-regional scale during the Neolithic and Chalcolithic periods (Hourani et Courty, 1998). This study permitted to recognize that the catchment basins of each tributary of the Jordan river and the different parts of the Jordan valley itself – upper, middle and lower parts – present a specific geological and geomorphic configuration. This results in marked contrasts between the sedimentary facies of the various late quaternary alluvium and slope deposits. Therefore, the mineralogy, petrography and texture of the fine mass and coarse inclusions – as observed in thin section – have revealed to be diagnostic criteria for recognizing the origin of the raw materials. Thus, the clay materials made of partly decalcified coarse clay that have been extracted from the local soils of Abu Hamid – within a ca. $1\ \text{km}^2$ area – during the Chalcolithic period can be easily distinguished from the highly calcareous, very fine clay which was at this time abundant in the marshlands of the Jordan river at a few km from the site itself. We have also observed a marked petrographic and mineralogical contrast between the various clay materials that are available in the small region of Abu Hamid from the ones of the adjacent valleys. This enabled us to clearly identify the locally made ceramics from the ones of other sites of the region, and, even, to isolate ceramics made of an unusual clay material coming from another region (Roux et Courty, 1997). Nine groups of clay materials were recognized (Roux and Courty, 1997).

In addition, the facility to control environmental factors, which are of major importance for tackling ceramic technology, has allowed to easily identify a large range of anomalies of the properties of ceramic clay that could not be of natural origin. They were logically concluded to express human intervention. Thus, the modal distribution, angular shape, freshness of coarse inclusions and the marked textural contrast between the latter and the fine mass can clearly be assigned to the addition of a carefully selected coarse temper to a well prepared clay. On the contrary a

petrographic and granulometric continuum from the coarse inclusions to the fine mass is more likely to be of natural origin with minimal effects of human intervention.

As a consequence, the combination of the criteria used to identify origin of the clay materials and the ones used to evaluate human intervention has helped to subdivide the ceramic clays of Abu Hamid into different categories which reflect both environmental and technological factors (Table 1).

The properties of subject's intention are variable because they depend both from the nature of the intention and from the properties of technical knowledge and environment. To the contrary to the environmental and technical factors, they are not "granted" data such as the ones issued from well established fields like physics, geology, chemistry or biology.

2. The wheel fashioned vessels

By reference to diagnostic attributes, it appears that the V-shaped bowls were not wheel thrown but wheel shaped according to the following main steps : coiling the roughout; joining the coils by discontinuous pressures ; thinning and shaping the roughout with the help of rotative kinetic energy (RKE) (Roux and Courty, 1997).

90% of the bowls appear to be made from a specific type of clay material (category 3) which is not present in the Jordan valley and surrounding basins, but well known in the Negev region (Roux et Courty, 1997). This shows that a great majority of the bowls was imported from the Negev. To the contrary, the other 10% of bowls appear to be made of various clay materials that are either from Abu Hamid region itself (category 1) or from other regions of the Jordan valley (category 2). These clay materials were also used for making non wheel fashioned vessels. They show a large range of transformations of the original materials (cf. Table 1) which contrasts with the minimum transformation of the source materials - loessic soils- used for the Negev bowls (Roux et Courty, 1997).

In terms of subject's intention, only V-shaped bowls have been fashioned on the wheel. There is no transfer of the technique to any other shape of bowl. These bowls represent around 50% of Abu Hamid ceramic production. However, the quantification of the annual production shows that the rate of production was very low (130 per year, Roux and Courty, 1997:39).

Discussion

Combined analysis of the three technological parameters enable us, as a first step, to propose hypotheses on the function of the V-shaped bowls which is a major element to define more precisely potter's intention.

One property of technical knowledge is determinant : the skills involved in the wheel fashioning technique. These skills gives to the V-shaped bowls a value of "high technology", given the fact that they are complex and long to learn and that only these bowls have been made on the wheel. In addition, 90% of these V-shaped bowls have been imported from far away (Negev) whereas they could have been made locally according to the coiling process or the wheel shaping technique. The latter technique was known from potters of Abu Hamid, and, furthermore, not constrained by the properties of the clay material as demonstrated by the large range of clay

materials that were used for wheel shaped vessels. The absence of transfer of the wheel technique to other functional categories of pots as well as their massive importation suggests that the V-shaped bowls had a distinct status that was not domestic, but, by opposition, ritual. This hypothesis is reinforced by contextual data according to which V-shaped bowls have been systematically found in burials and ritual places (Levy and Holl, 1988).

At this stage of our research, the analysis of innovation of wheel shaping in terms of cultural choice would lead to conclude that innovation of the wheel shaping technique is a response to a demand which was highly cultural. However, such an interpretation would ignore the evolutionary potential of techniques and would not explain why the invention of the wheel shaping technique came into being at this given moment.

In terms of evolutionary potential of techniques, the wheel was attested as a positioning device in the course of the coiling process as shown by some diagnostic surface features present on coiled vessels. The use of RKE for fashioning clay walls represents a technical invention in terms of exploitation of new source of energy. As any technical invention, it can be seen as the result of a dynamic process contained in ceramic forming techniques (Leroi-Gourhan, 1945, Gally, 1986).

In southern Levant, the wheel shaping tradition - which represents a major discontinuity in terms of skills compared to the local traditions - appears then as the result of a complex interaction between two factors : a technical invention that is characterized by exploitation of the rotative kinetic energy for shaping pots and a demand for particular ritual vessels. This complex interaction has resulted in technical innovation in specific conditions that are defined here by the organization of production and communities at the macro-regional level.

In terms of organization of the production, the constraint of skills suggests that the potters who made the V-shaped bowls were craft specialists - given the long apprenticeship to master the wheel fashioning technique (Roux and Corbetta, 1989, Roux, 1990). They were very few : in order to master the craft, potters had to practice with a minimum of vessels ; the low production could not be, therefore, distributed between a too high number of potters.

At a more general level, if V-shaped bowls were made for ritual purpose, it follows that their large distribution, from Negev to the different sites of southern Levant, reflects the emergence of a politico-religious community in the southern Levant during the 4th millennium BC. This hypothesis is supported by spatial data (Levy and Holl, 1988).

The complex interaction between technical knowledge and potter's intention takes place thus in a context where ceramic production is a specialized activity, and the new demand relates to a profound change at the politico-religious level. This context represented in southern Levant, the **conditions of actualization** for innovation of the wheel fashioning technique.

3. The coiled vessels

The hypothesis is that a systemic analysis should also account for explaining differentiation between two sub-traditions which distinguished themselves by distinct *chaine opératoire* that are not characterized though, by any technical innovation.

Tradition A or “ the slip group ”

Tradition A is the predominant one. It has been observed on vessels of different types, morphological (different shapes and dimensions) and functional (jars, bowls, churns, cooking pots...). It is characterized by wall surface with a *coarse grain* external aspect. Rim present horizontal parallell striations whereas external and internal walls present oblique subparallell striations. External bases present either a mat impression or a coil one which attests the use of the coil as a forming support.

Diagnostic attributes enable us to identify the main steps of the forming process : pots are coiled ; after joining the coils and thinning the walls, the external walls are smoothed with the fingers while still humid. As a result, temper comes out from the clay and gives a “ grained ” aspect. Internal walls may be smoothed with the fingers or with a tool. In the latter case, the walls present a sleek aspect. Both walls are then covered with a slip which is more or less thick depending on vessels. Slip is applied on the rim with a piece of cloth and on the walls with a brush according to a downward movement. Some vessels display rims which could have been shaped with the help of rotative kinetic energy. It makes us suppose that for some of them a rotative device was used as a “ positioning ” device.

The tradition A vessels appear to be made from all the different types of clay materials recognized from the entire Abu Hamid ceramic assemblage, except for the Negev one (cf Table 1). However, this tradition is characterized by the systematic presence of a coarse temper which is, in most cases, well sorted and well calibrated. Presence of very fine fissures, rare vughs, lack of an interconnected network of fine cracks and low porosity of the paste show that the incorporation of the coarse temper was well controlled and did not weaken toughness and strength of the vessels, whatever the nature of coarse inclusions are – platy shells, angular calcite, subangular limestone, flaky cherts, rounded basalts and carbonates, quartz. Cracks are slightly more developed for the type A vessels that are locally made (category 1.1b) due to the greater abundance of sands in the original clay materials, although the cohesion and density of the solid mass are not significantly affected. Type A vessels can thus be concluded to be, either, locally produced or to come from other production centers of the region and, to all have been made by potters who had a solid knowledge of the mechanical constraints of heterogeneous materials.

Tradition B or “ the non slip group ”

Tradition B has been observed on a few vessels, mainly small size vessels. It is characterized by walls which present a fine grain aspect. Rim present subparallell striations whereas external and internal walls present oblique strokes of subparallell striations. External bases of vessels present only mat impression.

Diagnostic attributes enable us to identify the main steps of the forming process : pots are coiled; after joining the coils and thinning the walls, rim is fashioned with a piece of cloth without the help of rotative kinetic energy. The internal and external walls are smoothed with a hard tool according to a vertical movement while the clay is still humid. No slip is applied. No rotative device was used as a “ positioning ” device.

Contrarily to tradition A, tradition B vessels are made only from the clay materials that was available at the site of Abu Hamid itself. No temper is

added (category 1.1a in table 1). Similarly to the type A vessels also made from this coarse clay materials, high density and low porosity of the fine mass show that the properties of the vessels were not affected by the high sand content.

Discussion

The two traditions correspond to two different intentions in terms of wall aspect. These intentions can be achieved with the different clays present in the environment as long as a careful preparation of the clay is achieved. The coarse grain aspect necessitates inclusion of coarse temper which requires a careful wedging in particular when using the local sandy clay.

Differences in the *chaîne opératoire* as well as specific attributes like the type of support upon which the pots are formed and the range of morphological types suggest that the two traditions may correspond to two groups of ceramic production which could reflect differences in potter's group or status of the vessels.

These hypotheses need now to be enriched by a more detailed analysis at the site and regional level. However, if we want to test our systemic approach, it appears already that it would be extremely difficult, in this case, to disentangle the factors at the origin of the two traditions A and B : the specific preparation of clays and finishing processes can be considered as a response to social logics,; however, clay presents constraints in relationship with the potter's intention. Thus, these constraints induce specific clay preparation.

It seems therefore more appropriate to analyze such technological situation in systemic terms and to consider that constraints and/or properties of environmental and social elements interacted to give for giving. Further studies of ceramic and contextual data should enable us to highlight the conditions under which differentiation of these two traditions came into being.

Conclusion

In this paper, we explained why technological analysis of technical traditions should consist to isolate the different parameters at stake in technical actions in order to understand the complex interaction that links their different elements. This implies a combined analysis of environment, technology and archaeology. The systemic approach that we have adapted offers the advantage to leave behind the structuralist concept of technological choice. The latter puts into correspondence technical and social elements and proposes eventually this correspondence as an explanation of the technical phenomenon under study.

The systemic approach studies the emergence of technical traditions in terms of complex phenomenon. The conditions of actualization are given by the local context into which it takes place. These conditions may vary because they depend on the technical phenomenon (innovation, borrowing, differentiation...) as well as its characteristic in terms of continuous or discontinuous transformation. In the future, comparative studies should enable us to assess to better define how the transformation of technological systems might have responded to general laws.

Bibliography

- Courty, M.-A., and V. Roux 1995 Identification of wheel throwing on the basis of ceramic surface features and microfibrils. *Journal of Archaeological Science* 22:17-50.
- Dobres, M.-A., and C. R. Hoffman 1994 Social Agency and the Dynamics of Prehistoric Technology. *Journal of Archaeological Method and Theory* 1:211-258.
- Dollfus, G., and Z. Kafafi 1988 Abu Hamid, un jalon dans le temps et dans l'espace. In *Abu Hamid, village du 4e millénaire de la vallée du Jourdain*, edited by coll., pp. 51-52. Economic press, Amman (Jordanie).
- Gallay, A. 1986 *L'archéologie demain*. Belfond, Paris.
- Gilead, I. 1988 The chalcolithic period in the Levant. *Journal of World Prehistory* 2:397-443.
- Hourani, F and M.-A. Courty 1998 L'évolution morpho-climatique de 10 500 à 5 500 BP dans la vallée du Jourdain. *Paléorient*, 23/2 : 95-105.
- Ingold, T. 1993 The reindeer's lasso. In *Technological choices. Transformation in material cultures since the Neolithic*, edited by P. Lemonnier, pp. 108-125. Routledge, London and New York.
- Lemonnier, P. (editor) 1993 *Technological choices: Transformation in material cultures since the Neolithic*. Routledge, London and New York.
- Leroi-Gourhan, A. 1945 *Evolution et techniques. Milieu et techniques*, vol. 2. Albin Michel, Paris, 2d édition 1973.
- Levy, T. E., and A. Holl 1988 Les sociétés chalcolithiques de la Palestine et l'émergence de chefferies. *Archives Européennes de Sociologie* XXIX:283-316.
- Pfaffenberg, B. 1992 Social Anthropology of Technology. *Annual Reviews of Anthropology* 21:491-516.
- Roux, V. 1990 The psychological analysis of technical activities : a contribution to the study of craft specialization. *Archaeological Review from Cambridge* 9:142-153, Technology in the humanities.
- Roux, V., and M.-A. Courty 1997 Les bols élaborés au tour d'Abu Hamid : rupture technique au 4e millénaire avant J.-C. dans le Sud Levant. *Paléorient* 23:25-43.
- 1998 Identification of wheel-fashioning methods: technological analysis of 4th-3rd millenium BC oriental ceramics. *Journal of Archaeological Science* 25:747-763.
- Roux, V. in coll. with D. Corbetta 1989 *The Potter's Wheel. Craft specialization and technical competence*. Oxford and IBH Publishing, New Delhi.
- Simondon, G. 1958 *Du mode d'existence des objets techniques*. Aubier, Paris.

Table 1 – Classification of Abu Hamid ceramics with respect to origin of clay materials and modes of preparation.

1 – Local ceramics

Sub-type	Group	Origin of clay materials	Fine mass	Coarse inclusions
1.1a	GVI	Local colluvial soils	Slightly calcareous, reddish brown coarse clay Weakly modified	Natural: weakly sorted, fine calcareous sands and quartz No temper
1.1b	GVI	Local colluvial soils	Slightly calcareous reddish brown coarse clay Weakly modified	Natural: weakly sorted, fine calcareous sands and quartz Temper: 5-10%, weakly sorted, medium to coarse sands (calcareous grains, basalt and flakes)
1.2	GIII	Marshlands of the middle Jordan river	Highly calcareous, yellowish brown, very fine clay Not modified	Temper: 5-20%, well sorted, coarse to very coarse, rounded sands (calcareous grains, basalt and flakes)

2 – Exogenous ceramics from the Jordan valley

2.1	GV	Upstream marshlands of the middle Jordan river	Non calcareous, brown, very fine clay Moderately modified	Temper: 20-30%, very well sorted, rounded, alluvial sands
2.2	GIV	Upstream lateral basin (Pella)	Very fine, strongly calcareous, brownish yellow clay Moderately modified	Temper: 5-20% weakly sorted, medium to coarse sands (limestones and cherts)
2.3	GII	Adjacent lateral basin	Dull orange, strongly calcareous fine clay Moderately modified	Natural: abundant, silt-sized micro-fossils Temper: 5-15% weakly sorted, medium to coarse sands (bioclastic limestone)
2.4	GVII	Adjacent lateral basin	Pale brown, calcareous fine clay Moderately modified	Temper: 5-25% well sorted, angular, medium to coarse sands (shell fragments)
2.5	GVIII	Adjacent lateral basin	Brownish yellow, strongly calcareous, very fine clay Moderately modified	Temper: 5-15% weakly sorted, subrounded medium to coarse sands (bioclastic and dolomitic limestone)

2.6	GIX	Adjacent lateral basin on Lisan marls	Pale grey, strongly calcareous, silty clay Weakly modified	Natural: well sorted fine sands (quartz and carbonates) No temper
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3 – Exogenous ceramics from other regions

3	GI	Exogenous (Negev loess)	Slightly calcareous, yellowish brown, silty clay Weakly modified	Natural: rare, poorly sorted, fine calcareous sands
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