

## The use of trace elements in the archaeological classification of cherts

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### Introduction

Rocks consisting of micro-crystalline or sub micro-crystalline accumulations of silica have been sought by man since earliest times, as their fine grain size, homogeneity, hardness, and conchoidal fracture make them ideal for the production of cutting edges for tools and weapons.

The widespread distribution and extensive use of these rocks has resulted in them being given a multiplicity of names, some of great antiquity. Textural and colour variations can justify some of these names. However, it is convenient to have a term which covers all rocks of this type, and in modern geological literature chert is the term which is becoming increasingly accepted.

Electron microscope and x-ray diffraction studies of cherts show that there are considerable variations in texture and mineralogy, with apparently identical cherts containing varying amounts of quartz, tridymite, cristobalite and opal.

### Chert types

A study by Grunau (1963), on the world-wide distribution of cherts, showed that they could be divided into two major categories on the basis of the associated rocks, and, by implication, the environment of their formation. The group containing the greatest volume of chert is associated with deepsea sediments and sub-marine lava flows. These cherts frequently contain the remains of siliceous organisms particularly radiolaria and their origin is related to the re-distribution of silica in sediments unusually rich in this type of organic debris.

The second main group of sediments found associated with cherts are limestones and sandstones of a shallow water marine nature. Cherts from this second group provide the raw material for most of the chert implements found in Western Europe and around the Mediterranean.

### Origin of chert

An understanding of the origin of chert and the environment of deposition of the associated rocks is essential before a chert classification based on trace element composition is attempted (Sieveking et al 1972).

As the cherts associated with shallow water marine sediments appear to be the archaeologically significant group,

this discussion will be restricted to that type of chert. The research on this topic up to the early 1960 is well summarised by Smith (1960). The mineral phase found in cherts is called chalcedony and consists of micro-crystalline silica, usually alpha quartz, in the form of plates and rods, with micro-pores between the micro-crystals, (Midgley 1951, Peltó 1956 and Micheelson 1966).

Chemical, and optical and electron microscope studies of this material indicate that it is not of primary depositional origin, but is formed during diagenesis by the re-distribution of siliceous material (Walker 1962, Buurman and Van Der Plas 1971).

The chemical behaviour of silica is such that it can be dissolved and precipitated by relatively small changes of pH in the natural environment (Alexander et al 1954, Krauskopf 1956 & 1959, Okamoto et al 1957, Siever 1957). The nature of the chert produced by this process depends on the host sediment in which the chert forms and the site or sites at which the crystals are nucleated. In limestones the cherts are formed by the replacement of calcium carbonate (Brown et al 1969, Buurman & Van Der Plas 1971, Folk & Weaver 1952, Micheelson 1966 and Walker 1962). There is good evidence that this is a molecule by molecule process and not precipitation into a cavity, as original carbonate depositional features, for example, oolites, laminations and fossils are preserved in silica. Indeed, in the cortex of Chalk cherts (flints) partially replaced coccoliths have been observed by Diver (personal communication). This replacement process results in the preservation of the non-carbonate material that existed in the limestone in the chert that replaces it. This non-carbonate material is the prime source of the trace elements in this type of chert. In quartz sandstones the chert normally occurs as a cement binding together the pre-existing detrital grains. The detrital grains are the main source of trace elements in this type of chert.

### Archaeological considerations

If the concentration and proportions of trace elements in cherts are to be of value in the identification of the source of raw materials of man-made artifacts certain conditions must be fulfilled. First, the material from each site must not vary widely in its trace element composition. Second, the trace element composition of material from sites being compared must be sufficiently different to avoid confusion. Third, the material in which the trace elements are located must not be affected by historically long periods of exposure in soils or similar environments. Finally, the

trace elements used for the study should be those that will be uniformly distributed through the chert and not those that are likely to be concentrated in occasional rare mineral grains.

Chalk chert (flint) taken from a particular horizon in a restricted locality would answer the criteria set out above. The composition of the Chalk at any particular horizon is, except in the marginal facies, and in certain 'hard grounds', uniform in composition. There are however, significant variations with time which are reflected in variations of non-carbonate mineralogy from one horizon to another. As these cherts are produced by replacement, material from one horizon will contain reasonably uniform trace element compositions (if suitable trace elements are chosen). However, variations will be significant from one horizon to another (Sieveking et al 1970), so one site will be discernable from another. Chalk cherts are dense and have low permeability, which reduces the possibility of removal of trace elements by leaching, or addition of material from ground waters.

The use of this technique identifying cherts derived from impure limestones or sandstones should be undertaken with extreme care as lateral variation is likely to be considerable, resulting in a variation of trace element composition within one site greater than, or as great as, that from one site to another.

### Conclusion

The trace element composition of chert artifacts cannot be used as a universal guide to their source. Implements from some sources will never be suitable for study by this technique. However, if used carefully on suitable material the technique can be of considerable benefit to the student of archaeology.

### REFERENCES

- Alexander, G. B., Heston, W. M. and Iler, H. K., 1954. The solubility of amorphous silica in water. *Jour. Phys. Chemistry* **58**, 453-455.
- Brown, G., Catt, J. A., Hollyer, S. E. and Ollier, C. D., 1969. Partial silicification of Chalk fossils from the Chilterns, *Geol. Mag.* **106**, 583-586.
- Buurman, P. and van der Plas, L., 1971. The genesis of Belgian and Dutch flints and cherts, *Geol. en Mijnb.* **50**, 9-28.
- Diver, W. Personal communication.
- Folk, R. L. and Weaver, C. E., 1952. A study of the texture and composition of chert, *Amer. J. Sci.* **250**, 498-510.
- Grunau, H. R., 1963. Radiolarian cherts and associated rocks in space and time, *Ecologiae Geol. Helv.* **58**, 157-208.
- Krauskopf, K. B., 1956. Dissolution and precipitation of silica at low temperatures, *Geochim. et Cosmochim. Acta* **10**, 1-26.
- Krauskopf, K. B., 1959. The geochemistry of silica in sedimentary environments, In Ireland, H. A. (ed.), *Silica in Sediments*, Soc. Econ. Palaeontologists and Mineralogists Spec. Pub. 7, 4-9.
- Micheelson, H. W., 1966. The structure of dark flint from Stevns, Denmark, *Medd. Fra. Dansk Geol.* **16**, 285-368.
- Midgley, H. G., 1951. Chalcedony and flint, *Min. Mag.* **88**, 179-184.
- Okamoto, G., Okura, T. and Goto, K., 1957. Properties of silica in water, *Geochim. et Cosmochim. Acta* **12**, 123-132.
- Pelto, C. R., 1956. A study of chalcedony, *Am. J. Sci.* **254**, 32-50.
- Siever, R., 1937. The silica budget in the sedimentary cycle, *Am. Mineralogist* **42**, 821-841.
- Sieveking, G. de G., Bush, P., Ferguson, J., Craddock, P. T., Hughes, M. J. and Cowell, M. R., 1972. Prehistoric flint mines and their identification as sources of raw material, *Archaeology* **14**, 151-176.
- Sieveking, G. de G., Craddock, P., Hughes, M. J., Bush, P. and Ferguson, J., 1970. Characterization of flint mine products, *Nature* **228**, 251-254.
- Smith, W. E., 1960. The siliceous constituents of chert, *Geol. en Mijnb. n.s.* **22**, 1-5.
- Walker, T. R., 1962. Reversible nature of chert-carbonate replacement in sedimentary rocks, *Geol. Soc. Am. Bull.*, **73**, 237-242.