The Oldest Quarries Known: Stone Age Miners in Egypt

The oldest known chert quarrying sites, dating from about 50,000 years ago, were recently discovered near Qena on the Nile River in Egypt. The quest for chert or other usable raw materials for making stone tools was always important in prehistoric societies. Archaeologists and anthropologists are increasingly interested in understanding how the need for raw materials was met in those times, although it has long been known that chert mines were operated by prehistoric people. Until recently all chert mining sites reported were younger than 12,000 years, most from 6,000 to 4,000 years old. These sites were associated with changes in economies and the growth in population that accompanied the spread of early agriculture in Europe and the Near East.

The Chert Quarry of Nazlet Safaha

Recent work by the Middle Egypt Prehistoric Project of Leuven University (Belgium) has led to the discovery of an extensive Old Stone Age (Middle Palaeolithic) chert exploitation area at Nazlet Safaha, near Qena (Fig. 1). This site is located on an unweathered remnant of a Nile cobble terrace and is still quarried for gravel. This cobble terrace is one of several Nile bedload deposits, intercalated between the Middle Pleistocene Dandara silts and younger silt deposits. These coarse terrace deposits contain mainly metamorphic and volcanic clasts, but also quartz and chert cobbles up to 0.2 m.

Figure 1: Location of sites studied. Floodplain (shaded area) and lower desert (dotted).

In January 1988 we excavated an area (sites 1 and 2) of about 3000 m², which had been exploited in Middle Palaeolithic times. Chert cobbles had been extracted from the uppermost part of the terrace deposits in open trench or pit systems, about 1-2 m wide and up to 1.7 m deep. In the northern part of the site, exploitation was so intensive, that an area of more than 1000 m² had been completely worked over.

The heterogeneous infillings of the exploited trenches are composed of pure sands, cobbles or a mixture of both and suggest an exploitation in different steps (Fig. 2). Prehistoric workers probably scraped off the sterile sands from small surfaces, dumped the sands behind them and extracted the cobbles individually. No excavation tools have been

recovered, suggesting that they either did not exist or were made from organic materials such as wood, bone or antler, which have not been preserved. The worker picked out the chert cobbles and sometimes also the thickest quartz pebbles. Other types of cobbles were dumped in the immediate vicinity, mostly in the trench itself. Matrix material from the terrace deposits is concentrated at the base of the infilling and on top of the in situ cobble deposits, suggesting that it was not removed from the trench during the chert removal process, and that it probably hampered or even prevented further extraction in depth.

Huge quantities of Middle Palaeolithic artifacts and rare charcoal fragments are incorporated in the trench and pit fillings. Some of the pits contain large quantities of chipped chert artifacts. In the course of the extraction, fine sands were blown into some exploitation pits, as deduced from the fact that some of the artifact accumulations are stratified in aeolian deposits. The absence of running water deposits or water erosional features in the trench filling, also suggests that climate during the exploitation periods was hyperarid.

Figure 2: Section through exploration trench at Nazlet Safaha, site 2. 1- loose fine and medium, mostly aeolian sands, with desert pavement on top; 2- man-made heterogeneous fill; 3- consolidated medium grained sands (substrate); 4- Nile cobble terrace (substrate); 5- edge of Middle Palaeolithic trench; 6- Middle Palaeolithic artifacts.

After the abandonment of the area when the exploited surface was littered with cobbles and artifacts, the whole area has been levelled by denudation and an aeolian cover has filled the pits. Finally, a desert pavement, bearing a dark desert varnish, has formed over the whole surface, covering filled pits, aeolian deposits and dump materials. We believe this desert pavement is man made, for it is mainly composed of artifacts and of extracted cobbles. Our excavations at the outer edges of this desert pavement indicate that its extension is a very suitable indicator for the delimitation of the prehistoric exploitation area. Overall, the impression is that the site was rather unstructured, probably as a result of intermittent exploitation.

The lithic artifacts recovered represent a Levallois technology, belonging to the classical Levallois group as defined by Van Peer and Vermeersch (in press), and point to a Middle Palaeolithic age for the exploitation. This is supported by

Figure 3: Middle Palaeolithic artifact layer in the trench infilling at Nazlet Safaha site 2.

the discovery at another site nearby of artifacts representing the Nubian technology. Similar ones have also been recorded at other sites in the Egyptian Nile valley, such as Nazlet Khater-2 and Beit Allam (Fig. 1). These sites are considered to be older than 60,000 years, when the region is thought to have been more humid. Since, the Nazlet Safaha site is coeval with an hyperarid climate, it is probably somewhat younger, we estimate around 50,000 old. Radiocarbon dating of charcoal fragments is in progress.

A detailed survey of the surface of the terrace remnants and along all recent quarry fronts in the Nazlet Safaha area revealed the presence of other exploitation sites. Discontinuous quarrying activities lasted probably over a long period of time, starting at least in the Middle Palaeolithic but probably continuing over some ten thousands of years into late Palaeolithic times.

At Nazlet Khater (Fig. 1), we excavated an early Upper Palaeolithic chert mining site with an exploitation system of trenches, vertical shafts and horizontal galleries, ^{14}C dated at 33,000 years ago (nine dates on charcoal). Like Nazlet Safaha, the site is situated on a Nile terrace remnant, composed of two layers: a lower one of well-rounded channel lag gravels with chert cobbles at the base, and an

upper one of brown grainy silts. This Nile terrace remnant is covered by local limestone gravels.

Comparison of the Middle and the Upper Palaeolithic trenches shows an important evolution. The later extraction system differs from the earlier in that exploitation was more regularly planned with parallel trenches at fairly constant intervals so that the whole area could be exploited without loss of cobble deposits. Vertical shafts and subterranean chert exploitation may be an Upper Palaeolithic innovation unknown in Middle Palaeolithic times.

As far as presently known, the quarrying sites of Nazlet Safaha and the mines of Nazlet Khater represent the oldest exploitation locations of raw material intended for manufacturing tools. Middle Palaeolithic sites have been reported from elsewhere in Nubia, the Swiss Jura and from northeastern Hungary, but the exact age of the exploitation systems are not known, because of later Neolithic workings that have thoroughly disturbed the evidence. The Late Palaeolithic open pit for the extraction of flint at Oronsko in Poland, dated between 12,000 and 11,000 yBP, lacks evidence of underground exploitation techniques. Middle Stone Age people did mine hematite at the Lion Cavern in Swaziland perhaps 110,000 years ago by cutting an adit into the side of a cliff face, but Nazlet Khater represents, by far, the oldest underground chert mining site known.

Chert quarrying at Nazlet Safaha, where no chert cobbles were visible at the surface, testifies that Middle Palaeolithic humans already had the intellectual capacity to reason geologically. Observations during an initial extraction were extrapolated tens of metres to indicate that exploitable cobbles were present elsewhere under a thin cover of sterile sands. Middle Palaeolithic exploitation techniques were simple but well adapted to the chert occurrence in these fluvial deposits.

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New Projects for IGCP

Twelve new projects were approved recently by the Board of the International Geological Correlation Project (IGCP), bringing the current total to 55 projects.

Project 234:

Precambrian Volcano-Sedimentary Complexes in West Africa (1989). Leader: I. Yacé (Dépt. des Sciences de la Terre, Université d'Abidjan, BP 22, Abidjan, Côte d'Ivoire). Accepted provisionally for one year, this project succeeds IGCP 108/144 on the Precambrian of West Africa and its correlations with Brazil. It will study the geochronology, structural relationships, metallogeny and volcanology and sedimentology of Archaean and Proterozoic complexes of West Africa and related regions.

Project 253:

Termination of the Pleistocene (1989). Leader: J. Lundqvist (Dept. of Quaternary Research, Odengatan 63 S-113 22 Stockholm, Sweden). This provisionally accepted project will study the global water budget by means of the relationship, causes and interaction between climate,

pluvials and interpluvials, oceanic regime, and sea-level and environmental change. It will extend to both high and low latitudes in southern and northern hemispheres.

Project 267:

Palaeozoic Terranes in the Circum-Pacific Orogens (1989-1993). Leaders: M.J. Rickard (Dept. of Geology, Australian National University, GPO Box 4, Canberra, ACT 2601, Australia) and Guo Lingzhai (Dept. of Geology, Nanjing University, Nanjing, China). A successor to IGCP projects 27 (Caledonide Orogen), 233 (Circum-Atlantic Terranes), and 279 (Terranes of Latin America), this will compare the tectonic and palaeomagnetic syntheses of terranes around the Pacific. A series of terrane maps and correlation charts will be prepared as the basis for strato-tectonic terranes analyses, crustal profiles, tectonic maps and models for the evolution of the orogens.

Project 275:

Deep Geology of the Baltic Shield (1989-1993). Leaders: F.P. Mitrofanov (Geological Institute, Kola Branch of

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U.S.S.R. Academy of Sciences, Fersman Street 14, SU-184 200 Apatity, U.S.S.R.) and R. Gorbatshev (Dept. of Geology, Lund University, Sölvegatan 13, S-223 62 Lund, Sweden). This project will develop theoretical and practical methods to develop crustal and geodynamic models of the Baltic Shield using geological, geophysical and geochemical data. Emphasis will be placed on applying and testing plate tectonics in the Precambrian, and correlations will be made with the basement of the East European Platform and other Precambrian cratons.

Project 281:

Quaternary Climates of South America (1989-1993). Leader: A. Argollo Bautista (Centro de Investigaciones Geológicas, UMSA, Casilla de Correo 12198, La Paz, Bolivia). The aim is to obtain a better understanding of climatic processes such as the consequences of past changes in soils, vegetation and human distribution. Studies will be made of biological, geological and hydrological markers in the sedimentary record, with the focus on the last great climatic cycle in the Quaternary, and possibly on the Pliocene-Pleistocene changes. Past climatic variations will be used as the basis for a quantitative climatic model.

Project 282:

Rare-Metal Granitoids (1989-1993). Leaders: Zhu Jinchu (Dept. of Earth Sciences, Nanjing University, Nanjing, China) and P.J. Pollard (Dept. of Geology, James Cook University, Townsville, Queensland 4811, Australia). A successor to Project 220 on Sn/W granites, this will study rare metals (eg. Ta, Nb, Li, Be, Sn, W, Mo, and Bi) granitoids and associated mineral deposits. Exploration techniques and strategies will be considered as will the geotectonic environment and the magmatic and post-magmatic evolution of rare-metal mineralizing systems.

Project 283:

Evolution of Paleo-Asian Ocean (1989-1993). Leaders: Xiao Xuchang and He Guoqi (Institute of Geology, Chinese Academy of Geological Sciences, Baiwanzhuang Road 26, 100037 Beijing, China), N.L. Dobretsov (Geological Institute, Buryat Academy Centre, Pavlov str. 2, 670015 Ulan Ude, U.S.S.R.) and R.G. Coleman (Dept. of Geology, Stanford University, Stanford, CA 94305-2115, U.S.A.). This project will study the tectonic evolution of Paleo-Asian domains during Paleozoic and Precambrian time using key geological formations, paleomagnetism and palinspastic tectonic methods. A study will be made of the amalgamation of Precambrian blocks and relics of the PaleoAsian ocean and the transformation into mobile belts between the Siberian and North China platforms.

Project 287:

Tethyan Bauxites (1989-1993). Leaders: A. Mindszenty (Eötvös L. University, Museum krt 4/A, H-1088 Budapest, Hungary) and I. Jurkovic (University of Zagreb, Pierottijeva 6, 41000-Zagreb, Yugoslavia). This project will correlate Mesozoic to Tertiary karst bauxite and paleo-karst horizons with orogenic, eustatic, and climatic events already recognized within the Tethyan realm from Spain to Iran. Relevant geological, geochemical, mineralogical, petrological, stratigraphic, sedimentological and geophysical data will be compared.

Project 291:

Metamorphic Fluids and Mineral Deposits (1989-1993). Leaders: W. Franks (Institut für Geologie, Universität Wien, Universitätsstrasse 7, A-1010 Vienna, Austria) and W. Prohaska (Institut für Geowissenschaften, Montanuniversität Leoben, A-8700 Leoben, Austria). This project will study the formation of ore deposits that are related to regional metamorphic processes, concentrating on vein-type deposits (eg. siderite, barite, gold, scheelite,

and low-grade thermal Pb/Zn). Investigations will involve fluid inclusion studies, isotope and geochemical analyses and leaching experiments.

Project 294:

Very Low-Grade Metamorphism (1989-1993). Leaders: R.E. Bevins (Dept. of Geology, National Museum of Wales, Cardiff CF1 3NP, U.K.) and D. Robinson (Dept. of Geology, The University, Bristol BS8 1RJ, U.K.). The aim is to define more closely the realm of very low-grade metamorphism. The project will advance studies by which P-T and fluid activity are determined. Comparisons will be made between different regions of low-grade metamorphism and correlations and calibrations will be carried out among the various methods and techniques used (e.g. mineral facies, illite crystallinity, coalification, fluid inclusions, conodont colour). A suitable terminology will be developed.

Project 296:

Quaternary in the Asia-Pacific Region (1989-1993). Leader: J.L. Rau (ESCAP Natural Resources Division, UN Building, Bangkok 10200, Thailand). Two main objectives are to establish a network of Quaternary geoscientists interested in stratigraphic correlation and Quaternary geology "for human survival," and to make a firm regional chronostratigraphic classification of the Quaternary deposits, taking into account stratotypes from onshore and offshore areas.

Project 297:

Geocryology of the Americas (1989-1993). Leader: A.E. Corte (Geocryological Lab. CRICYT, Casilla de Correo 330, 5500 Mendoza, Argentina). This project will identify present and past glaciogenic processes and correlate them across the Americas and to other parts of the world. Studies will be undertaken on freezing processes and geochemistry, sedimentary features in cold environments, how to distinguish the results of freezing in cold deserts from those due to evaporation processes in warm ones, and ways to use permafrost as a natural refrigerator.

Five new members of the IGCP Scientific Committee began their terms of office in 1989: D.L. Dineley (U.K.), I. Premoli-Silva (Italy), R.A. Price (Canada), A. Y. Rozanov (U.S.S.R.), and C. Schlüchter (Switzerland). There were also five new members of the IGCP Board: A.A. Bellizzia (Venezuela), S. Karamata (Yugoslavia), K.L. Kauranne (Finland), A.H. Kazmi (Pakistan), and Xie Xuejing (China). The new Chairman of the Board is A.J. Naldrett (Canada), with B.A. Baldi (Argentina) as Vice-Chairman.

The IGCP Secretary, E. Dudich (Hungary), reported that the overall funding available for IGCP in 1988 was US \$277,500, up 5.2% over the 1987 amount. The contribution from Unesco had, however, increased marginally, from \$171,800 in 1987 to \$173,500 in 1988 (The sum for 1989 is only \$143,100, according to the new Board Chairman), with the balance made up largely by contributions from the U.K. and the U.S.A. (non-members of Unesco) through IUGS. Moreover, the 1988 total had to be spread over a larger number of projects, for which the average funding was US \$5,550, a decrease of 7.9% over 1987 levels.

Progress towards the Global Change Program

Last August, the ICSU Special Committee for the International Geosphere-Biosphere Programme (IGBP) on Global Change published its "Plan for Action." This was reviewed in October by the IGBP Scientific Advisory Council (SAC) at the Royal Swedish Academy of Sciences in Stockholm. A measure of the potential commitments to the IGBP is given in reports presented by some 50 national and international organizations. In the words of the Swedish Minister of the Environment, Birgitta Dahl, "We are also prepared to support international research actively in order for the problems of global change to be clarified. It is our hope that your work will succeed in promoting a more profound understanding among decision-makers in various parts of the world. It will take time to reverse current developments and that is why we need to start now."

During the two years that have elapsed since ICSU decided to launch the Global Change Programme it has become ever more obvious that a joint international effort, of the kind that is being considered, is of fundamental importance for the future habitability of the planet. It will document changes of world concern in the global environment, both as these occur now and as they have transpired in the past.

To many, the IGBP is now seen as an essential element in rational management of the common natural resources of the Earth, as recognized in the United Nations-sponsored Brundtland Report, *Our Common Future*, *A Plan for Sustainable Development*. A Global Change Program directed at a better understanding of the Earth system will reduce the uncertainty in analyses and predictions of how the environment will be altered in the future. This should lead to more prudent policy decisions on the part of all the governments of the world.

The success of the program will depend not only on collaboration among disciplines to study global processes, but also on the development of new approaches and techniques with-

in disciplines. There will also have to be a thoughtful balance between an organizational structure to support interdisciplinary research at the global scale and the need to foster new creative ideas that will arise from single investigators and teams of researchers.

There is an apparent paradox between the need for a bounded research program and that of understanding global processes. The program must therefore be defined to address issues that meet the priority criteria laid out in the original charge: "those areas of each of the fields involved that deal with key interactions and significant change on time scales of decades to centuries, that most affect the biosphere, that are most susceptible to human perturbation, and that will most likely lead to practical, predictive capability."

The Action Plan identifies four research themes:

Documenting and Predicting Global Change. This entails the identification of natural processes that contribute to global change by studying the record of the past, assessing the effects of current anthropogenic impacts on the coupling of biogeochemical processes and the physical climate system, and testing our understanding of these processes in predictive models.

Observing and Improving Our Understanding of Dominant Forcing Functions. Because of the great significance across the full breadth of IGBP-related research of the effects of external forcing, studies will be made of solar and orbital phenomena, crust-mantle processes and anthropogenic activities, as well as of the indeterminate natural forcing that arises from inherent short-term instabilities in the Earth system.

Improving Our Understanding of Interactive Phenomena in the Total Earth System. It is necessary to describe key interactions among physical, chemical and biological components of this system in order to assess their potential to produce rapid changes and sharp spatial gradients.

Assessing the Effects of Global Change that will cause Large-Scale and Important Modifications in the Availability of Renewable and Non-renewable Resources. Research efforts will be focused on sensitive areas most likely to be affected. It is necessary also to develop understanding and predictive capability at the regional level.

To develop the Program, five Coordinating Panels have been set up to identify the initial research objectives and to propose contents of projects in: Terrestrial Biosphere-Atmospheric Chemistry Interactions (Chairman: P.J. Crutzen), Marine Biosphere-Atmosphere Interactions (T. Nemoto), Biospheric Aspects of the Hydrological Cycle (S. Dyck), Effects of Climate Change on Terrestrial Ecosystems (B.H. Walker), and Global Analysis, Interpretation and Modelling (B. Bolin).

Two Working Groups are also helping to assess the current state of knowledge and future prospects of Data and Information Systems (S.I. Rasool), and Geosphere-Biosphere Observatories (R. Herrera). The activities of the Working Groups are spread across those of the Coordinating Panels and are concerned with all research themes of the IGBP.

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There was general agreement that the IGBP research phase should consist of specific core projects with precise objectives and specified methodologies and criteria, have a broad international base and exist for limited periods of time. The first of these has now been established, under the chairmanship of H. Oeschger, to study "Global Changes of the Past" (see *Episodes*, vol. 11, no. 4, p. 284). Core projects will be strengthened by other international research programs that can be expected to improve our understanding of global changes.

Some of these, such as the Global Energy and Water Cycle Experiment - a part of the World Climate Research Programme, the International Global Atmospheric Chemistry Programme, and the Joint Global Ocean Flux Study, are already underway or at an advanced planning stage. The SC-IGBP will seek close links with these projects and where appropriate joint sponsorship. These two types of core projects would be formally recognized by the Special Committee as essential to the achievement of the IGBP objectives.

The IGBP Council expressed a firm statement of commitment to initiate as soon as possible major new international research projects. These will deal with the role of biota in the cycles of chemicals in the atmosphere that give rise to the greenhouse gas effect, of oceanic organisms in the global carbon dioxide cycle, and of the land plants in the

exchange of energy and moisture between the land and the atmosphere. There will also be a coordinated effort to recover information from natural archives that will illuminate connections between atmospheric composition, global temperature, ice extent, solar history, and the distribution of land and oceanic organisms.

While the IGBP is international in scope and global in focus, its success will depend largely on national efforts. Thus, the program must recognize that it will be endorsed and eventually nudged to some degree through perceptions of how it contributes to various national priorities. Toward this end, the design of the program must be built with the aid of national programs and in the light of national and regional interests.

The importance of the human dimension of global change has been recognized since the inception of the IGBP, and several international organizations are developing a program in concert with the IGBP. These include the International Federation of Institutes for Advanced Study, the International Social Science Council, and the United Nations University. IGBP will, however, concentrate on a set of objectives that are limited to the fields of expertise of the members of the ICSU family.

After report by F.W.G. Baker
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Planning Global Research on the Cretaceous

A new international research effort on Cretaceous sedimentary geology is now well underway, organized by the new IUGS Commission on Global Sedimentary Geology. Entitled "Cretaceous Resources, Events and Rhythms," Project CRER will address global aspects of this period. The Cretaceous was selected because the sea levels and climates at that time can provide a vision of the Earth in its "greenhouse state," because there is an established geochronology for these widespread deposits, and because there are extensive resources in Cretaceous rocks including hydrocarbons, coals, and bauxites. At a recent planning meeting in Digne, France, five Working Groups and two Coordinating Committees were established to plan and execute the needed research, over both the short term (3-5 years) and the longer term (10 years).

The long-term goal of WG-1 (Sequence Stratigraphy and Sea-level Change) is to evaluate the role of eustasy in Cretaceous sedimentary cycles in the range of 1-10 Ma. The short-term strategy is to place time constraints on unconformity-bounded sequences from widely separated basins during a restricted time interval in the mid-Cretaceous in order to test their global synchronicity. WG-2 (Stratigraphy, Geochemistry, and Paleoceanography of Organic-rich Mid-Cretaceous Sequences) is directed towards understanding oceanic anoxic events that produced the widespread black shales, some of which are major source rocks for hydrocarbons. This Group will first establish a data base of uniform information on age, lithologic sequence, stable isotopes, and composition of organic matter, which can be used to test the global synchronicity of specific black shale events and to estimate the rate of accumulation of sediment, carbonate, and organic carbon.

The long-term goals of WG-3 (Cyclostratigraphy) are to increase time resolution beyond the approximately 1 Ma-level of biostratigraphy and to search for the records of Earth's orbital cycles, the Milankovitch Rhythms. To begin, this Group will standardize methods of describing and

analyzing cyclic sequences, explore for proxy indicators both chemical and magnetic, and begin the cooperative study of additional occurrences of cyclic sequences between some of the well-established localities.

For WG-4 (Carbonate Platforms) the long-term goal is to decipher the sensitive records of variations in productivity of skeletal sediments, sea-level change, and variations in climate. First it is necessary to standardize terminology and methods of description of carbonate facies and then to begin the characterization of platform growth and drowning during specific time intervals.

WG-5 (Paleogeography, Paleoclimatology, Sediment Flux) aims to characterize the record of extreme, end-member conditions during the Cretaceous: the ultra-warm period with high sea levels, and the cooler times when sea level was low. Existing maps and data of paleogeography and models of paleoclimates will provide the starting points, but much additional new data are needed.

Two Coordinating Committees were also established. One on Geochronology (CC-1) will combine and correlate all the existing time scales, with the goal of providing a practical, linear time scale for dating events and calculating rates, frequencies and durations of processes at the Earth's surface. A second Coordinating Committee on Data Management will provide advice on systems of data storage and retrieval.

There is much enthusiasm in the individual Working Groups for coordinated research on global-scale problems, and it is evident that the five key topics are so inter-related (e.g. sea level, anoxia, and paleoclimates) that the Project could well elucidate the inter-actions of global systems. For additional information on the Project write to GSGP Secretariat, University of Miami, Fisher Island, Miami Beach, FL 33139, U.S.A.

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