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„NATURKATASTROPHEN IN DER ANTIKEN WELT"

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Catastrophe, Chaos and Complexity:

The Death, Decay and Rebirth of Towns from Antiquity to Today

My interest in 'urban catastrophe' has been stimulated by a puzzling observation from my field project in Boeotia, Central Greece. The city of Haliartos was destroyed by the Roman army in 171 BC (BINTLIFF, SNODGRASS, 1988a). Curiously both the town and its countryside remained thinly populated till Medieval times, when a new small town emerged; when this was abandoned in the 17th century AD a further 250 years elapsed before refoundation. In contrast the regional centre, the large city of Thebes, despite wholesale destruction by Alexander, was refounded by Cassander within a few years, and within a few generations was extensive and prosperous again (SYMEONOGLOU, 1985), remaining the focus for Eastern Boeotia till the presentday. Why, we might ask ourselves, do catastrophes have such divergent outcomes for the development of towns?

Turning to natural catastrophes, the same paradox appears: it remains remarkable, that the violent earthquakes which threw down the Old Palaces of Minoan Crete (Fig. 1) led merely to their rapid rebuilding on an even grander scale (CADOGAN, 1976; MYERS, MYERS, CADOGAN, 1992) — the New Palaces, by a society that had all the characteristics of its predecessor.

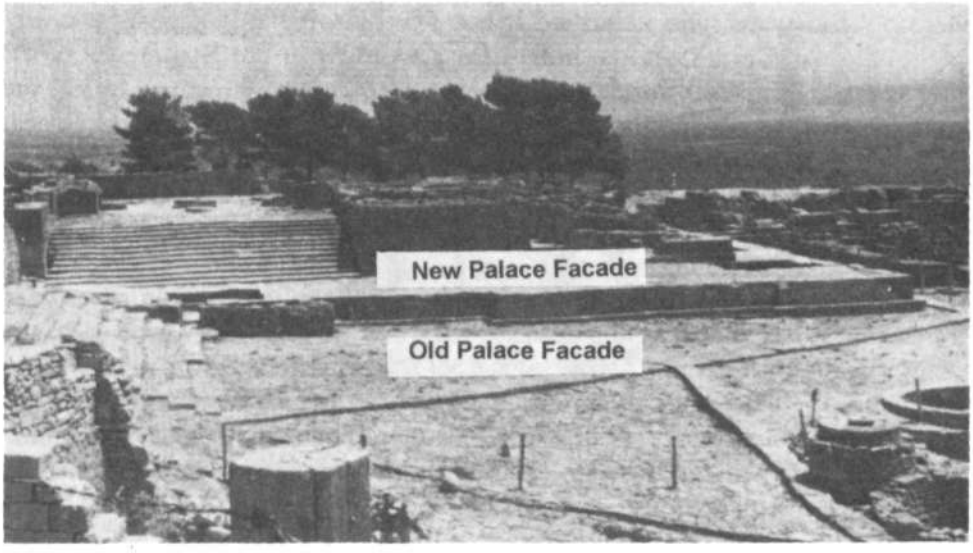


Fig. 1 The identical façades of the Old and New Palaces at Phaistos, Crete (from CADOGAN, 1976, Plate 24).

It seems that a catastrophe is unambiguous in the short-term, measured by loss of life and property; in the long-term, however, quite divergent consequences emerge, revealing a spectrum from continuing disastrous effects, via minor transformations of society, to a total absence of long-term effects.

I have recently been greatly stimulated by the implications for the social sciences of a package of theory enjoying widespread and interdisciplinary application in the Natural Sciences — Chaos and Complexity Theory (LEWIN, 1993; REED, HARVEY, 1992). In the world of Physics, Chemistry and Biology, there are endless phenomena where the building-blocks of the natural world can behave rather randomly — Chaos. Yet everywhere in Nature we see these components interacting systematically to form Complexity: the mutating genes that lie in all our body cells, for examples, or the individual animals in an ecosystem.

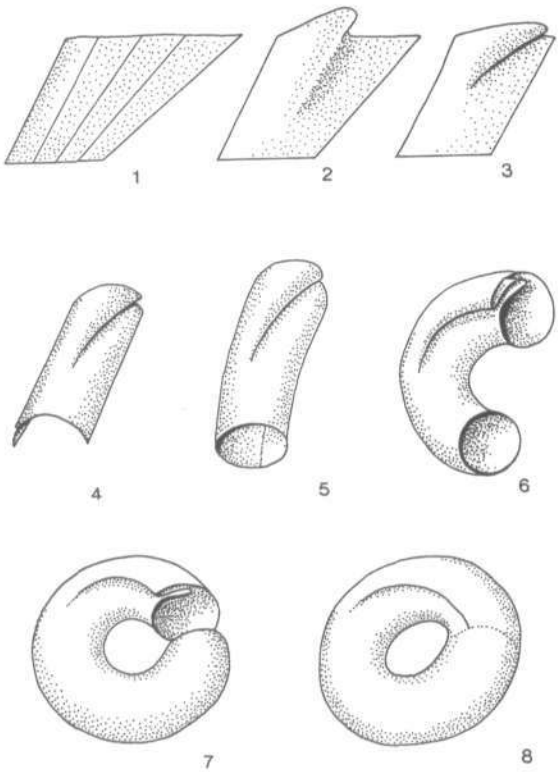


Fig. 2 'Folding phase space'. The topological folding of previously separate trajectories into one creates an attractor, known as Birkhoff's bagel (after J. GLEICK, Chaos. Making a New Science, 1987, 254).

Although *panta rei* — the natural world is constantly changing and evolving, is historical, these variable components are constantly being drawn, as if magnetically, into familiar or new complex structures. Mathematicians, who have inspired this interdisciplinary body of

theory, call these structures 'Attractors'. A single structure which draws in or attracts the behaviour of many components gives them a circular or doughnut-shaped path over time (Fig. 2). However, as both structure and components are always evolving semi-independently, a critical point can be reached in the parameters of the complex entity, where the system faces several outcomes — called a Bifurcation (Fig. 2). The system may be pushed towards one path and retain order, or take several and move towards fragmentation and ultimately chaos. The path to two parallel forms creates a dual or 'butterfly' attractor. It is considered that the reason why components are drawn into Attractors, thereby losing their independence at least temporarily to be part of a complex structure, is due to strong positive feedback where co-operation is mutually advantageous.

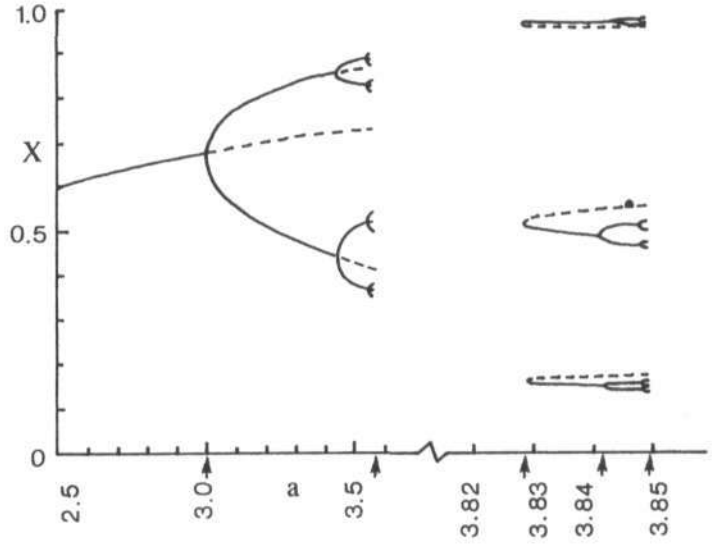


Fig. 3 An early bifurcation diagram based on innumerable repetitive computations of a logistic non-linear equation, illustrating the pathways into chaos (after J. GLEICK, Chaos. Making a New Science, 1987, 78).

The mathematics show that the path of any complex system at a bifurcation is heavily dependent on initial conditions: minor changes in the variables comprising a structure can lead it into rapid collapse, sustained complexity, or even a new level of complexity. Complexity Theory also teaches that the more elaborate such structures are, the closer to Chaos or risk of breakdown.

One final piece of theory: Fractals (Fig. 4). There are Attractors in the Natural World that operate in an identical way at a series of spatial scales — producing similar structures from the microscopic to the gigantic. These are called fractal patterns (here is the famous example of a simple branching pattern, which magnified to a series of nested spatial scales, mimics patterns of real-world organic growth such as a fern).

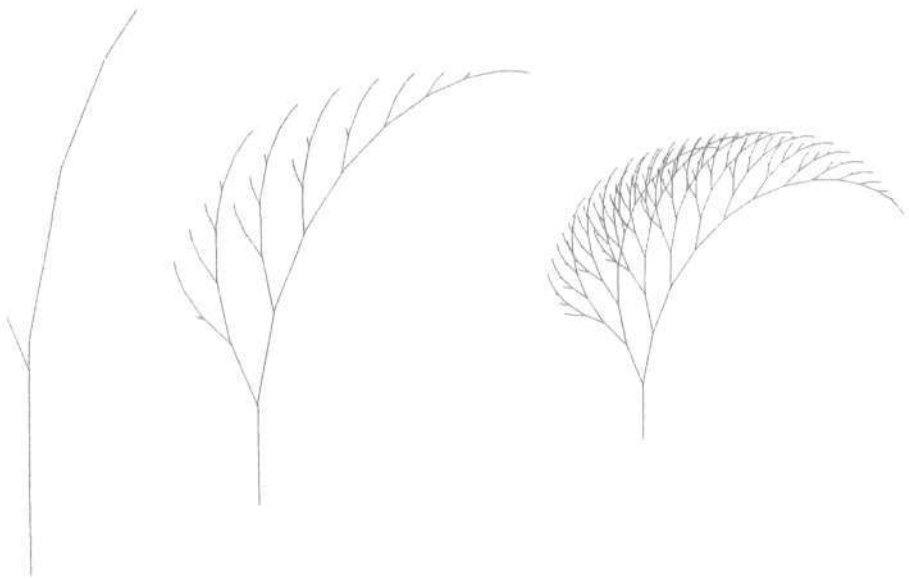


Fig. 4 A computer iteration of a fractal pattern which produces a simulacrum of natural growth, such as in a fern (courtesy of DAVID BYRNE).

Perhaps quite enough of typical Anglo-Saxon theory jargon (even if mostly derived from the Continent!): does it help us understand human societies? In the study of settlement history I believe it does. It has long been recognized that certain Attractors exercise a powerful influence on the size, function and spacing of villages, towns and cities in agricultural societies (BRUSH, 1953; TIDSWELL, 1978) (Fig. 5).

Spacing of settlement data in South West Wisconsin

	Hamlets	Villages	Towns
Number of settlements	142	73	19
Theoretical spacing (km)	8.5	16	31.7
Actual spacing (km)	9.4	15.8	34
Number of functions	2	18	42

Fig. 5 The hierarchy of settlements in mid–20th century Wisconsin. After TIDSWELL, 1978, Table 11.1, derived from BRUSH 1953.

Cross-cultural analysis of recent, ancient and prehistoric communities demonstrates a strong tendency for hamlet-village networks to develop at distances of 5–10 km interval; for district towns to develop at around 30 km interval. Settlement size (BERRY, 1967; TIDSWELL, 1978) (Fig. 6) divides towns and villages at around 2000 people. (Incidentally these generalisations have a high resonance with the work on ancient Greek towns carried out by EBERHARD RUSCHENBUSCH (RUSCHENBUSCH, 1985) and BRUNO HELLY and his colleagues at Lyon (AUDA, DARMEZIN, DECOURT, HELLY, LUCAS, 1991), and with ERNST KIRSTEN's Dorfstaat model (KIRSTEN, 1956), these connections being further explored in a recently published paper in this Stuttgart series (BINTLIFF, 1994)).

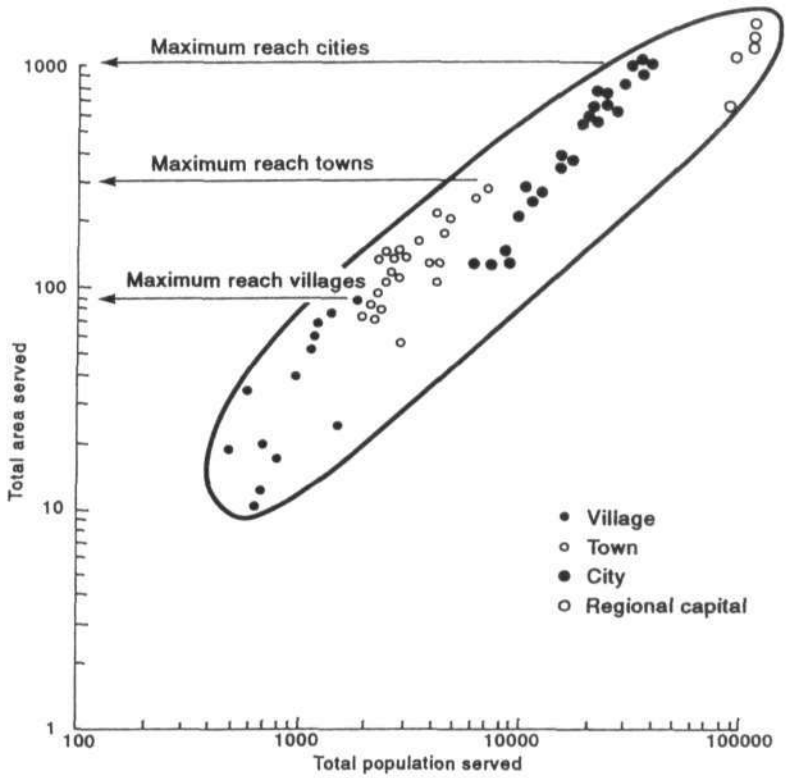


Fig. 6 Scatter diagram to show the variations in levels of the settlement hierarchy. After TIDSWELL, 1978, Fig. 11.1, derived from BERRY 1967.

There are ergonomic and sociobiological factors at work in these attractors, that I have discussed elsewhere. Likewise with urban settlements, Townscapes show strong cross-cultural tendencies wherever organic growth dominates over central planning in their layout, towards a certain kind of spatial differentiation (MEYER, HUGGETT, 1981) (Fig. 7), first analyzed by the Chicago School of urban geography. In ancient terms the 'Central Business District' is the Agora or Forum. I wish deliberately to introduce a practical example of an industrial town close to my university town of Durham – Sunderland (MEYER, HUGGETT, 1981; ROBSON, 1969) (Fig. 8), as it looked in the 1960s when an urban geographic analysis was carried out on its plan. I shall return to Sunderland later. We must merely note here that such spatially-complex town plans are cases of a single dominant attractor, where the life of all the separate classes and residential areas of the town is focussed on a few dominant economic activities, integrated politically, socially and economically through the Central Business District (Forum/Agora).

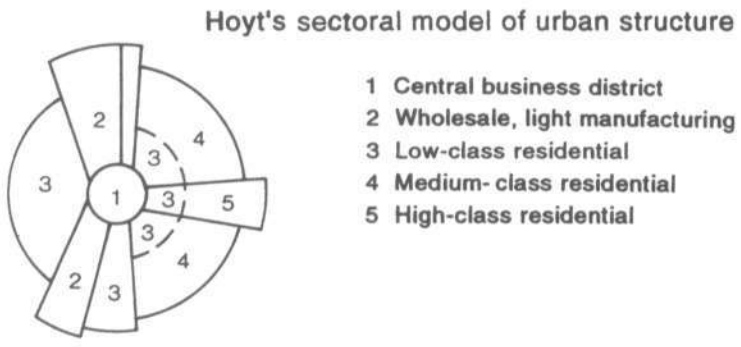


Fig. 7 Model developed in the 1930s by HOYT to describe the urban structure of modern cities. After MEYER, HUGGET 1981, Fig. 3.15.

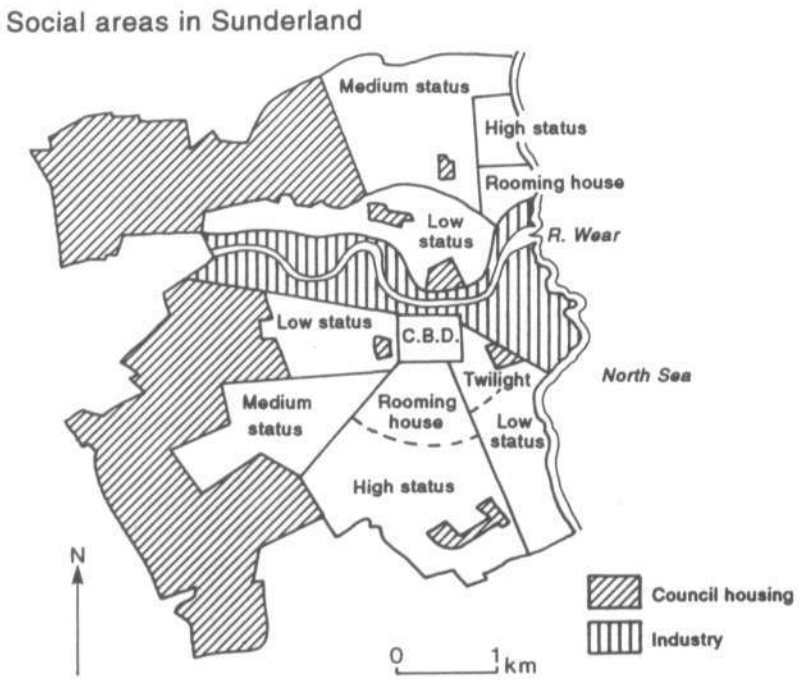
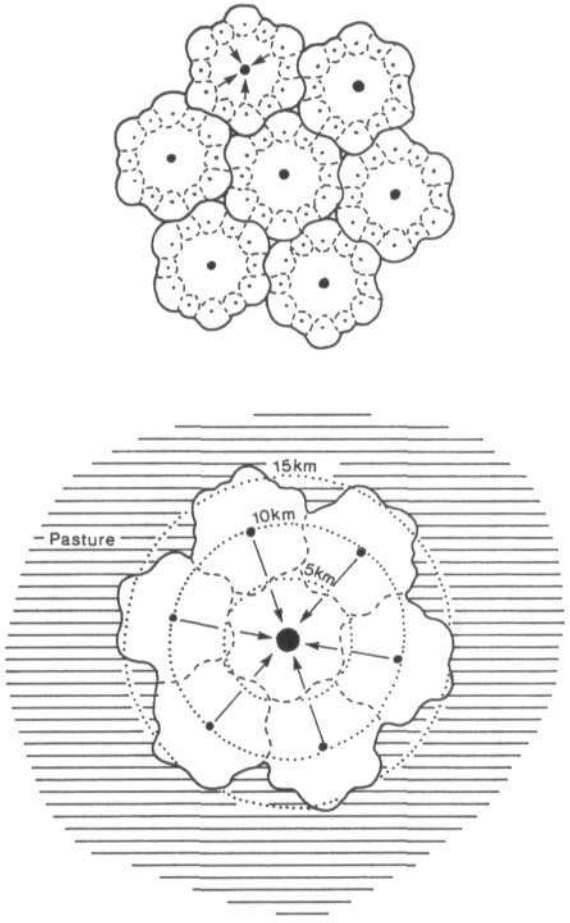


Fig. 8 Urban analysis of Sunderland by B. T. ROBSON, 1969. After MEYER, HUGGETT 1981, Fig. 3.16.

Let me now introduce some archaeological urban catastrophes. My first group of examples belong to the Early Bronze Age in the Levant and Mesopotamia. In a sophisticated series of studies, TONY WILKINSON has used his many years of fieldwork amongst the Early Bronze Age urban foci of North Mesopotamia to create a developmental model (WILKINSON, 1994). Large villages emerge (with satellite hamlets), due to familiar attractors at 10 km

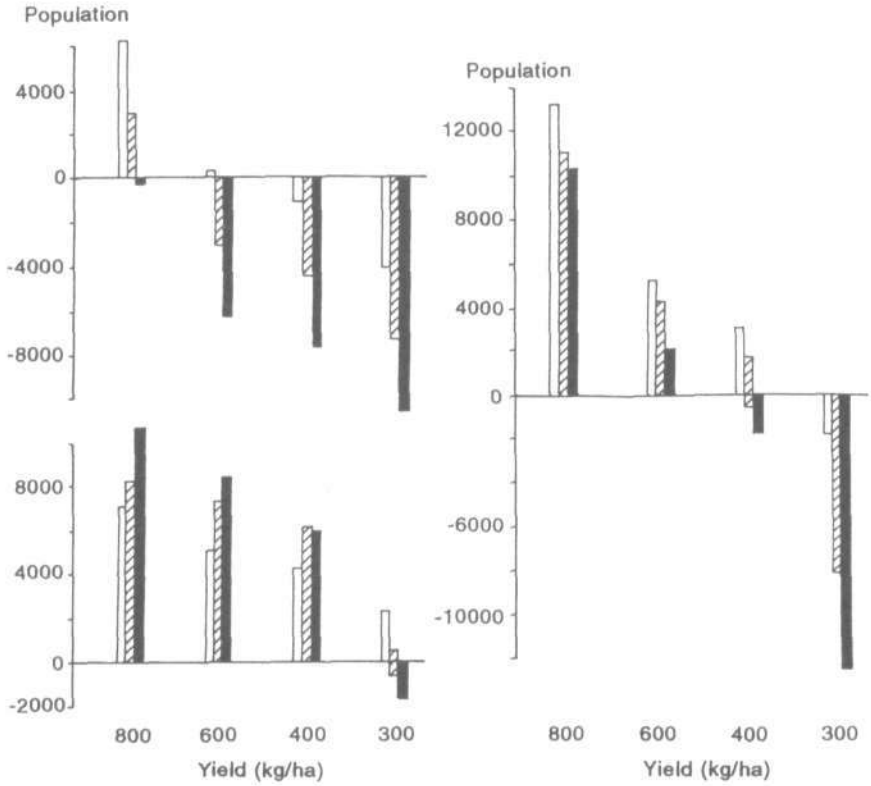
distance from each other. Later, towns grow organically out of this network, at familiar, c. 30 km radius from each other. In Complexity Theory such a convergent development from repetitive circumstances is termed 'self-organisation'.



Modular catchments illustrating the transformation from seven individual territories each of 5km radius (top) to a compound catchment incorporating the seven individual catchments (bottom). Because the lowest-order satellites may be temporary features of the landscape, they have been omitted from the lower diagram. Modified circles have been used to facilitate packing: production figures used in the text have been calculated from circular catchments. Shaded area, pasture.

Fig. 9 WILKINSON's model for the evolution of district central-places in Early Bronze Age North Mesopotamia. After WILKINSON 1994, Fig. 17.

The Central Place (Fig. 9) grows through controlling the surplus of its villages; they also grow due to the stimulus to intensify land use to feed the city. In a semi-arid, dry-farmed environment with recurrent rainfall fluctuations, this complex urban landscape is 'near the edge of Chaos'. WILKINSON calculates (Fig. 10) the growing imbalance of population versus resources, and the reduction of buffering mechanisms against crop fluctuations. He reveals the precariousness of urban life under Bronze Age technological constraints (as shown by the risk of total resource failure for the urban system under poor yield years on these graphs).



Surplus and deficit production (in persons supported per hectare) at different levels of yield generated by (top left) Tell al-Hawa, (bottom left) its secondary settlements, and (right) the settlement system as a whole at various population densities (white bars, 100/ha; shaded bars, 150/ha; solid bars, 200/ha).

Fig. 10 Sustainability of district central-place systems in Early Bronze Age North Mesopotamia according to differing population levels and cereal production levels. After WILKINSON 1994, Fig. 13.

In the late 3rd millennium BC this North Mesopotamian urban system does indeed collapse like a house of cards — to be followed by a settlement pattern of a reduced number of villages. HARVEY WEISS and a team of earth scientists have recently (WEISS, 1993) claimed that c. 2300 BC, when this occurred, the crop failures predicted by WILKINSON's model under 'normal' good year-bad year runs, were made unusually severe due to a drastic climatic fluctuation.

Also of Early Bronze Age date is the precocious Jordanian urban site of Jawa (HELMS, 1981) (but see PHILIP (1995) for caution over HELMS' scenarios for this remarkable site). Constructed in the pre-desert in an area of inadequate local rainfall for such a large settlement, it grew rapidly on the basis of elaborate water diversion and retention systems for torrential rains falling on higher ground to the north-west. Whether the rapid collapse of town life was due to internal social divisions or the inability to maintain the engineering system is unclear, but it seems likely that the 'complexity' of the town in such a situation was a high-risk ecological and social development unlikely to be sustained.

ARLENE ROSEN's study of Early Bronze Age urban sites in Palestine (ROSEN, 1995), especially Tell Erani, provides a similar story. A network of small defended towns emerges in Early Bronze II. Good environmental evidence from several approaches (Fig. 11) shows that climate had been growing drier since a moist era in the preceding Copper Age. At ROSEN's case-study site of Tell Erani a vital part of the town's crop production derived from a recent alluvial plain, created during that wetter climate era. However during the late 3rd Millennium BC there is widespread evidence for a further stage in the desiccation of climate in Palestine, associated with the removal of the alluvial plain by stream downcutting. Failure to compensate led to the collapse of town life at Erani.

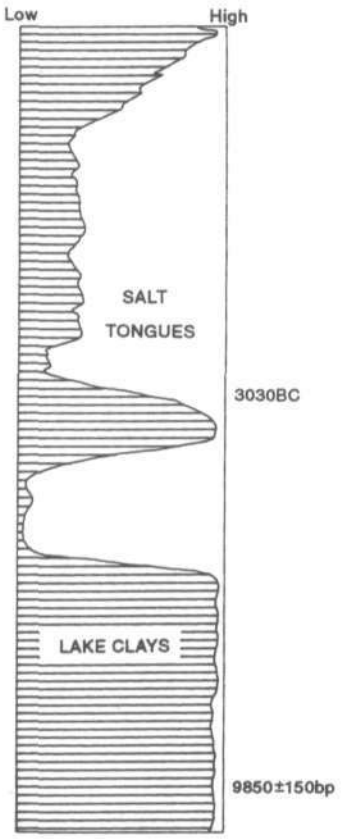


Fig. 11 Evidence for short-lived climatic fluctuations in the Copper Age – Early Bronze Age of the Levant. After ROSEN 1995, Fig. 2, derived from NEEV, EMERY 1967.

The parallels to events elsewhere in 3rd millennium urban sites are clear. But ROSEN sees this as a social and intellectual rather than simply ecological catastrophe. Despite the availability to Early Bronze Age communities of agricultural advantages unavailable to Chalcolithic predecessors (such as olives, vines, the plough), they failed to adapt to localised environmental deterioration.

In summary, Early Bronze Age urbanism in the Middle East appears to be complexity with inherent instability.

Let me now turn to another 'natural catastrophe': Plague Epidemics. We are all familiar with the awesome effects of the 14th century AD Black Death. It left its mark in terms of a population collapse (Fig. 12, from MORRIS (1989, figure 89) after HATCHER), from which recovery took several centuries, a significant contribution to the decline of Feudalism, and the conversion to pastoralism of marginal zones.

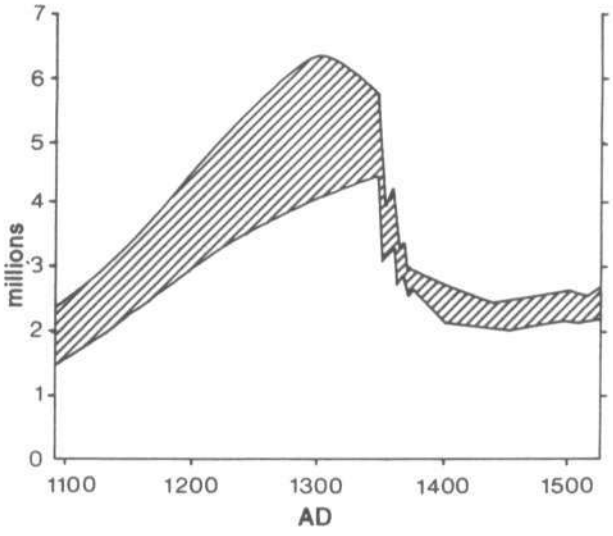


Fig. 12 Long-term flows in English Medieval population, with range between plausible limits. After MORRIS 1989, Fig. 89, derived from HATCHER 1977.

Yet the recurrence of a high-mortality Bubonic Plague in 17th Century AD Europe (Fig. 13, from SCHOFIELD (1989, figure 8.7), after WRIGLEY) had a very different set of consequences. Especially for England and France there were minimal effects on socio-economic life. The current specialist view on this contrast, particularly in the Cambridge Group for the History of Human Populations, is in accordance with our models, that initial conditions are critical to the path of human societal development (CAMPBELL, 1993; WALTER, SCHOFIELD, 1989).

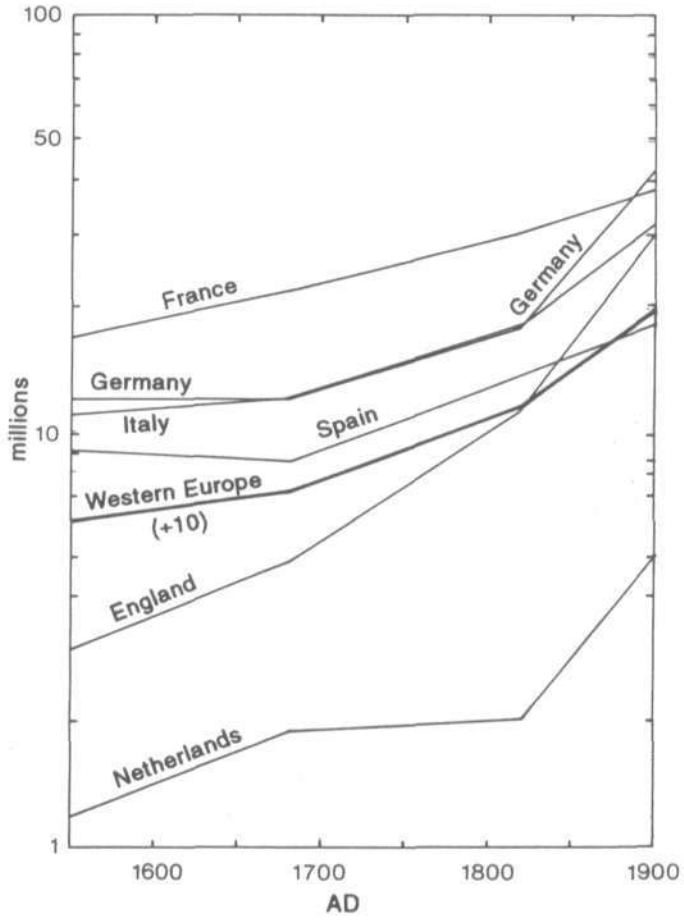


Fig. 13 Population growth in Western Europe. After SCHOFIELD 1989, Fig. 8.7, derived from WRIGLEY 1985.

By the 14th Century much of Europe was overpopulated, overcultivated and inefficiently farmed, usually in the context of a feudal economy which inhibited agricultural development; communications were poor between regions; and state action in health was rudimentary. The dramatic collapse of population, in the West of Europe at least, allowed a reorganisation of the countryside towards regional specialization of production; with poor communications this meant low populations in pastoral areas and abandonment of the most marginal lands. Population recovery was therefore slow.

By the 17th Century however, state bureaucracy was more efficient in containing plague attacks. Regional specialization in food production was now combined with improved communications to create a national food exchange, so that famines became rare and crop failures met through the flow of complementary food types between regions.

The conclusion of current studies of Bubonic Plague epidemics is that long-term effects are more indicative of the varying socio-economic structure of afflicted areas, than of the potential of the disease to influence history at that scale.

My final example for urban catastrophe follows on from this discussion, as it concerns the effect of the famous Bubonic Plague of the 6th Century AD in the Mediterranean.

In the decades before the 540's, the Byzantine Empire under Justinian reached, in its Eastern Provinces, a degree of populousness and wealth often unparalleled since Classical Greek times (BINTLIFF, SNODGRASS, 1988b). The successful campaigns of Justinian's generals looked set to restore to Roman power all the lost provinces of the West Mediterranean and North Africa. Yet between the end of the 6th and the middle of the 7th Century in the Byzantine world, most urban sites had been reduced to village status or abandoned, rural populations had collapsed, and the provinces, too weak to resist, were flooded by Slav, Berber and soon after Arab invaders. The incidence of Bubonic Plague, starting in the 540's but recurring till the 8th AD Century, is commonly given a major role in the 'catastrophic' decay of the Early Byzantine Empire and its urban network.

I want to take us back to earlier 20th Century AD Sunderland, in North-East England, to search for a deeper understanding of these phenomena. Recall to mind that picture of the high-employment, organic, integrated and 'Fordist' city of the 1960's — a classic single attractor city built on the interdependence of coal, steel and shipbuilding. Today, however, in the 1990's, we find a very different city. My colleague in the Sociology Department at Durham, DAVID BYRNE has argued (BYRNE, 1997) that in this, and other 'Post-Industrial' cities of northern and midland Britain, the 'catastrophic' collapse of traditional heavy industries has pushed the organic Fordist city into a bifurcation: now there are two city worlds in each town.

You are all familiar with this divergence of urban life in the Post-Industrial city (HARVEY, 1989): the prosperous, downtown consumer shopping malls with their Postmodern architecture and wealthy patrons, and the ghettoes of unemployment, crime and decaying buildings where riots are latent.

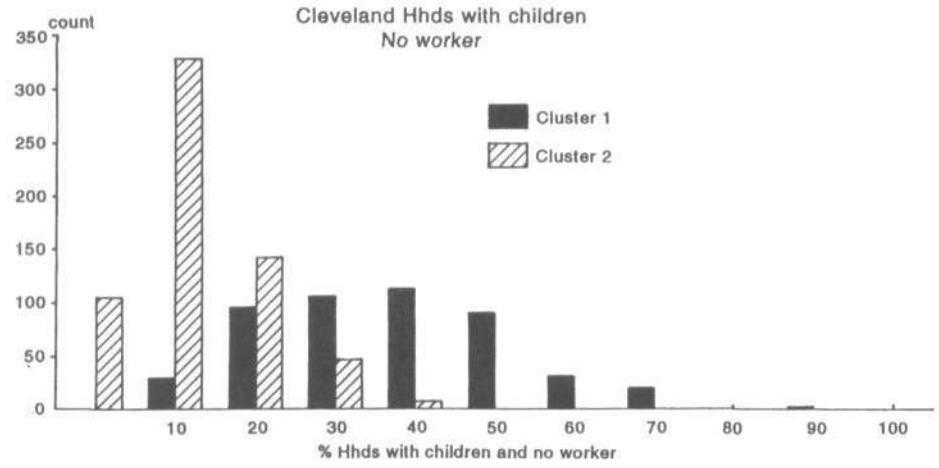


Fig. 14 Divergent population groups in contemporary 'post-industrial 'Cleveland, N. E. England. Courtesy of D. BYRNE (cf. BYRNE 1997 for a discussion of the study).

BYRNE uses statistical analysis and Chaos Theory to reveal these two divergent attractors, i. e. a butterfly attractor model (Fig. 14). His first, Factor 1 population, is high in unemployment, rented homes and often car-less. His Factor 2 population is rich in employment, mainly home-owners and car-owners. Byrne also suggests that global sociology indicates a fractal perspective to these observations in particular towns. In place of the 19th-early 20th Century world of First, Second and Third World economic belts, core-periphery areas of wealth and poverty spatially segregated by country and even continent, our Post-Fordist world of Flexible Capital and Multinational companies operates through a dislocation into rich and poor societies within every town and every country. The dual society runs right across the world at all spatial scales.

Let us take these insights back with us to focus on the Early Byzantine urban decline. In the Early Roman Empire a typical Greco-Roman town was a single attractor in our terms (Fig. 15 and 16(i)). Life focussed on the political, commercial, social, and religious activities of the forum or agora, the 'core' around which lay the different rich and poor housing sectors, all a 'periphery' which shared in the exploitation of the town's agricultural and mineral hinterland and the possibilities of external trade. The town lay (Fig. 17, modified after LEVEAU (1984)) as the core of a periphery of satellite settlements, mutually advantageous, and in a higher spatial scale the town is part of a provincial core-periphery relation with Rome itself.

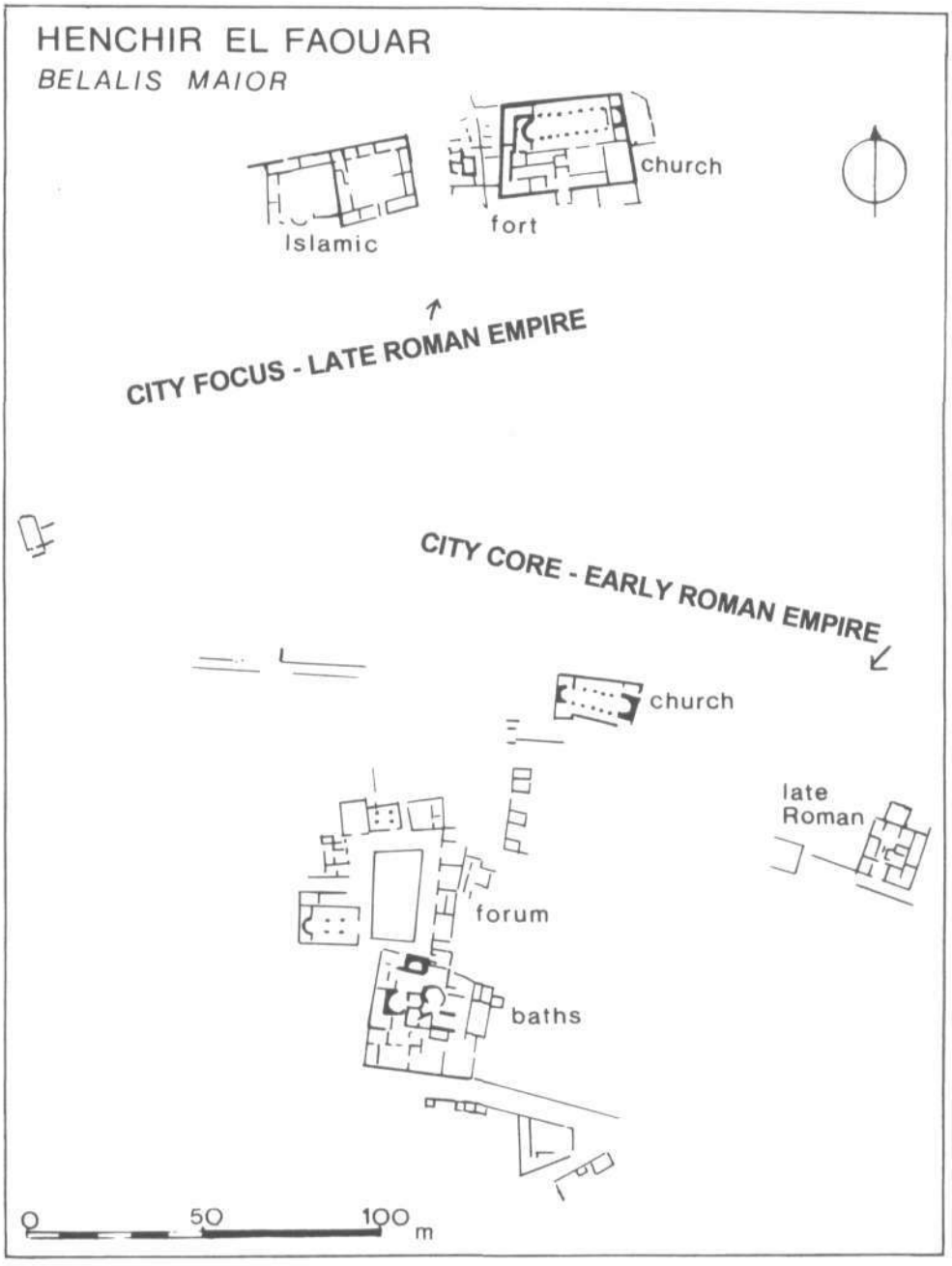


Fig. 15 Plan of Belalis Maior in Tunesia. After POTTER 1995, Fig. 33 and MAHJOUBI.

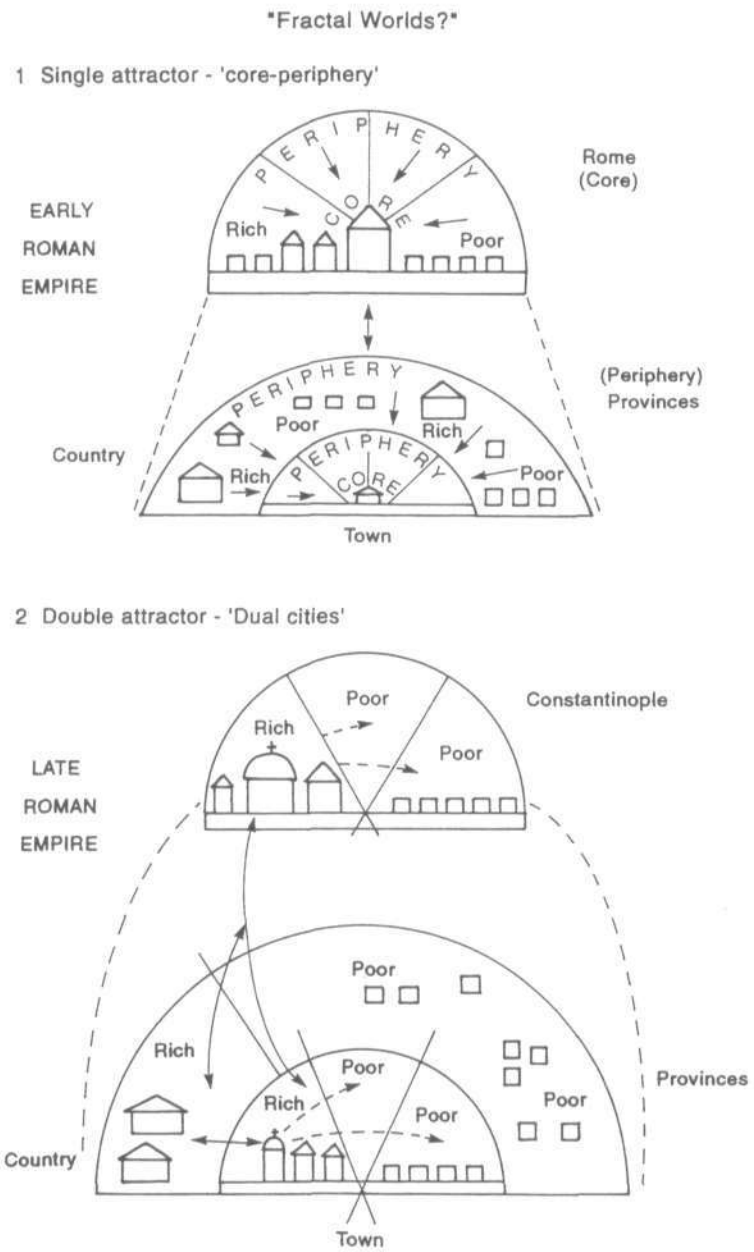


Fig. 16 Model for the transformation of a fractal society in town and country between Early and Late Roman times in the Mediterranean region.

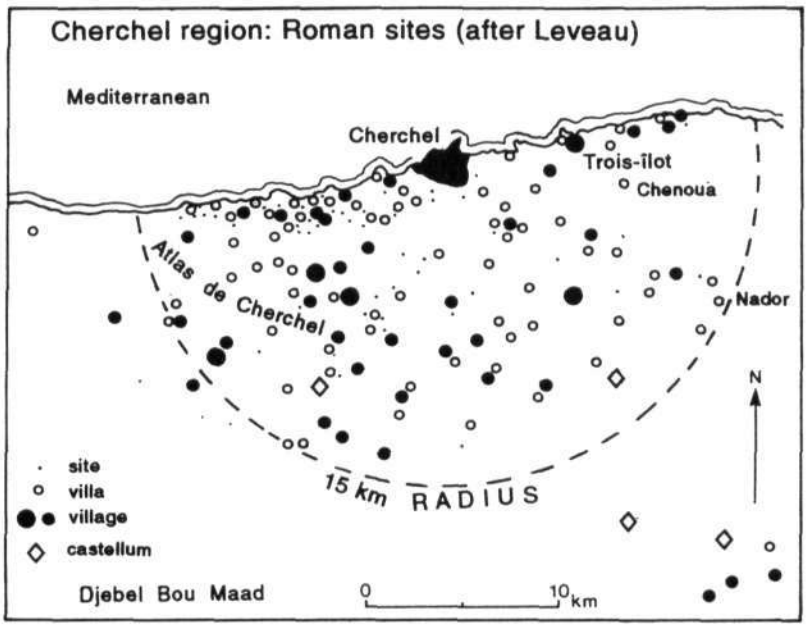


Fig. 17 A characteristic urban hinterland in the Roman Empire. The service catchment of the town of Iol Caesarea (Cherchel, Algeria), largely circumscribed by an access radius of 15 km (see Fig. 5). After POTTER 1995, Fig. 4, derived from LEVEAU 1984.

TIM POTTER has recently published (POTTER, 1995) an in-depth analysis of Early Byzantine period urban development in the Mediterranean from the 4th to 7th Centuries AD. In a careful study of excavations from Africa, Italy and the Eastern provinces, POTTER shows that usually from the late 4th Century AD most town fora are going out of use: slum housing spreads across the paving, burials and rubbish pits appear, even agricultural soils. Tumbled columns are left fallen and can be used as elements in primitive housing. The former, wide colonnaded streets are gradually filled with unpretentious wooden stalls, churches and even agricultural installations.

At the same time, in stark contrast, in the 5th-6th Centuries AD, usually in a different area of the town (Fig. 15 and 16(ii)), new buildings are being erected — often impressively large — Christian basilicas and the mansions of the wealthy. Here is a paradox. One school, usually historians, sees the Roman town as surviving till the 7th Century or even much later, since bishops are recorded, large churches, wealthy and literate people, clear signs of international trade goods. The other school, usually archaeologists, points to the undeniable physical decay of the town, and the dominance of slum construction, purposeful demolition and clumsy reuse of classical architectural spolia.

POTTER's conclusions are interesting:

- He sees no causation through the Vandal conquest or other military factors on these Byzantine town developments: the decline of the imperial town was already in progress
- Long-term economic and sociopolitical changes in the Roman Empire had broken the will and the ability of most town councils or rich individuals to invest in the urban infrastructure — apart from churches. Towns were increasingly being managed by imperial officials (cf. HALDON, 1990)
- Within the towns however the Christian church was taking advantage of the vaccuum in local affairs to create its own power-base, often deliberately remote from the forum. Around the new focus was taking shape the work of distributing food to the poor and a new hierarchy of patronage and economic control. Meanwhile in the traditional downtown zones and other remaining inhabited areas of the town an attractor of 'villagisation' is observable: people poor in material culture or artistic pretension are returning to a basic level of subsistence, and craft production of a less sophisticated kind. The Church, despite its close links to the wealthy class, offers a one-way welfare bridge to the poor sectors.

To this I would add from my own project database in Greece for this era the following suggestion: the core-periphery of the town and its hinterland also seems to be breaking up. Surplus crop production was perhaps going directly from the larger estates to the coast to feed Constantinople and other great centres rather than to the nearest town, or being consumed on the estate by populations that had left the town to seek the patronage of large landowners (cf. WHITTAKER, 1983).

The fractal view shifts accordingly (Fig. 16(ii)). The fragmentation of the Early Byzantine townscape in the dual city is reflected in the countryside, with the decline of the dependent relation between town and hinterland. Might we not look for the same divergence of town life in the city of Constantinople itself? Perhaps we do have evidence for this: in 532 AD the terrible Nika riots are reported to have left 30,000 dead and the centre of Constantinople burnt to the ground. CYRIL MANGO (MANGO, 1980) suggests that urban decay in the provinces had also reached the capital.

What effect might the Great Plague of the 540s and its recurrence afterwards have had on this longer process of urban decay? (Fig. 18, after RUSSELL, 1985, table 6) After it we see new urban bifurcations, a multiplicity of outcomes or a chaotic development. At least three development paths emerge. For most provincial towns the loss of population at all social levels might have so reduced the role of the town that a total villagisation may have occurred (perhaps some 116 of the estimated 372 Roman towns in Italy may have disappeared, for example (POTTER, 1995)). In other towns, often for geopolitical reasons, the Church retained a base, allowing the 'town' to continue officially even if its population was closer to a village (Luni seems to be a good example). Only the largest towns would have continued to attract sufficient population through administrative, military, and other considerations to allow a truly urban role to persist (and even their size was dependent on the sphere within which their 'command economies' could demand food from the areas of their political control, as the great shrinkage of early Medieval Rome and Constantinople testify, witness to the loss of their major grain provinces).

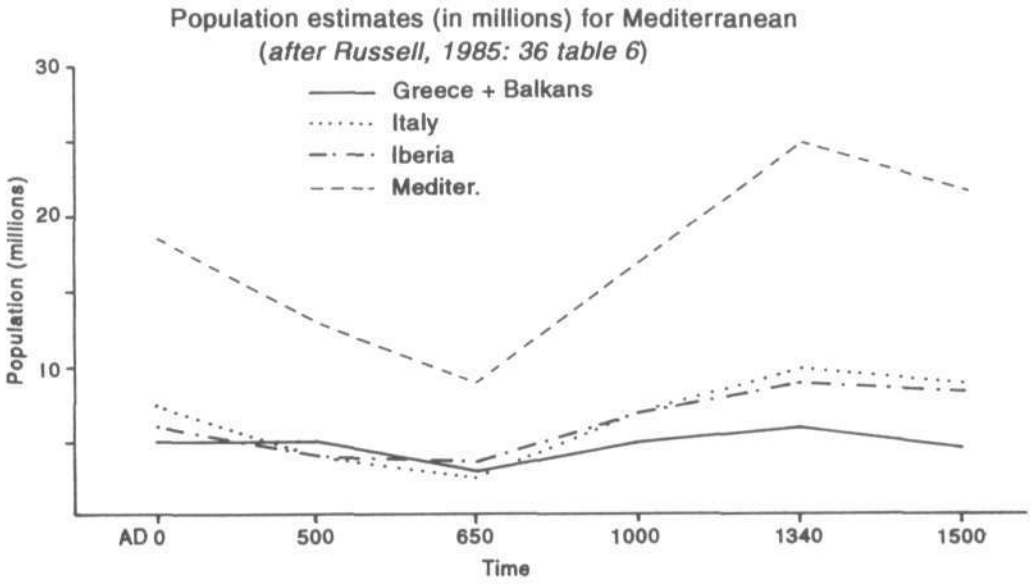


Fig. 18 Population estimates for the Roman to Medieval Mediterranean, after RISSEL 1985, Table 6.

Yet, as historians of demography have repeatedly shown, plague of itself does not create long-term population collapse. However, the breakdown of Early Byzantine urban structure towards a more chaotic form, was probably significantly hastened by the Plague. At this time of weakness, also, the conquest of large areas of the Byzantine countryside by Slav, Berber and later Arab settlers was made so much easier and further reinforced the urban disintegration process.

Once again it is to these contemporary conditions that we can attribute the outcome of the Plague rather than its own potential for culture-collapse. The decay of town life, but not necessarily of urban population, began much earlier, and I welcome ideas as to how to account for this. Some provisional suggestions are put forward in a concluding discussion to this paper. Also beyond the power of the Plague alone is the great urban and rural depopulation of the late 6th and 7th Centuries AD in the Mediterranean, often not recovered from till the 11th–12th Centuries AD (Fig. 18). More plausible to account for the latter phenomena is the role of endemic warfare and insecurity (BIRABEN, 1989; DURLIAT, 1989; for comparison cf. the impact of the Thirty Years' War in Central Europe (CERMAN, 1994)), factors which only began to disappear with the firm reestablishment of powerful Mediterranean states in the later 1st millennium AD.

In summary: I have argued that the variable consequences of natural and other catastrophes for urban life are primarily a result of the variable nature of urban societies, rather than due to any inevitable effects of such disasters. This inference accords excellently with the predictions of Chaos-Complexity Theory for the understanding of that complex human organisation we call the City.

Concluding Discussion

The investigation of structure-agency relations in comprehending the decay of classical antiquity is an essential step which will benefit from the rich participant- observer literature available to us from this era. Nonetheless, there is a central proposition in Complexity Theory that reminds us that the mere summation of individual motivation and action does not create society: the concept of 'emergent properties' argues that social and other elaborate structures are more than the sum of their component parts. The Roman Empire was a structure of immense complexity and surprising longevity; however, when complexity increases, Complexity Theory argues that it is ever closer to the edge of Chaos. How then do we explain the extraordinary persistence of that Empire? Many commentators have pointed to a potential causative link between the stabilisation of frontiers, cessation of expansion, and internal decay, both for the Roman and other imperial systems (e. g. the Ottoman).

This interesting observation could be brought into relation with that school of thought that sees ancient imperialism as a process of predator-prey expansion, growth of the core being conditioned by expansion of the resource catchment supporting the system (a view that FINLEY espoused, and modern scholars still find illuminating — such as JEREMY PATERSON for Roman expansion, and SIMON HORNBLOWER for Athenian expansion). In Complexity terms, the Roman Empire avoided 'chaos' by always altering the rules of its structure through continual expansion, until stabilisation by the 3rd Century AD; the decline of its oldest heartland, north-central Italy, by this time, might be predictable on this approach, if the structure became increasingly dependent on younger resource acquisitions. From the 3rd Century AD the inner decay of the Empire would correlate with the inherent instability of a very elaborate sociopolitical structure.

At the Durham interdepartmental Complexity Seminar, a parallel idea was raised to account for the creation of the 'dual society' in post-Industrial cities; this could provide additional insight into the late Antique urban decline we have compared it with. According to this hypothesis, in the expansion of the Capitalist economy from its origins in Renaissance Western Europe, growth of the system was dependent upon predation on less-developed economies in spatially-distinct geographical areas (WALLERSTEIN's world-system model). With the achievement of global capitalism and the removal of the colonial structures which favoured the core First World areas, the world economy has become unstable and prone to chaotic economic behaviour, as a result of the variability of the more-autonomous producing and consuming units across the world. Capitalism has gravitated towards a new attractor — Flexible Accumulation (HARVEY, 1989) which renetworks those with capital away from traditional sociopolitical structures (the city, region, state, continent) with the aim of protecting wealth from such local to general economic fluctuations. WHITTAKER's (1983) study of the very wealthy in Late Roman society would seem to echo this scenario. The impact on urban and social coherence would seem in good part accounted for in both late Antique and Post-Industrial situations.

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